

Prepared in Cooperation with
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Grays Harbor Sediment Transport Experiment Spring 2001—Data Report



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Cover photograph: Ocean Shores, Washington, is located on the north side of Grays Harbor inlet. This photograph was taken looking north on May 6, 2001, at the start of the Grays Harbor Sediment Transport Experiment.

Grays Harbor Sediment Transport Experiment Spring 2001—Data Report

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Summary

The Southwest Washington Coastal Erosion Study (SWCES) is a multi-year multidisciplinary investigation of the coastal region between Tillamook Head, Oregon, and Point Grenville, Washington, cosponsored by the U.S. Geological Survey (USGS) and the Washington State Department of Ecology. The Spring 2001 Grays Harbor Sediment Transport Experiment consisted of a series of measurements made near the entrance to Grays Harbor between May and July, 2001. This report describes data obtained during the spring 2001 experiment.

The objective of the spring experiment was to measure wave conditions during the time when beaches typically rebuild and to collect more comprehensive sediment-transport measurements. This portion of the experiment was accomplished by deploying six tripods near the entrance to Grays Harbor, Washington. These tripods contained pressure sensors, acoustic Doppler profilers, acoustic Doppler velocimeters, optical and acoustic backscatter sensors, and sonar instruments to measure waves, tides, currents, suspended sediments, and small-scale bottom morphology. Profiles of water conductivity and temperature as a function of depth (CTD profiles) were performed during the processes experiment, and sediment samples from the beach and instrument sites were collected. High-quality data were recovered from most of the instruments and have been included in this report. Instrument malfunctions and apparent discrepancies that should be taken into account during the interpretation of these data are described in this report.

To document seasonal morphological changes over the nearshore, a section of beach within the study area was regularly surveyed. Beach morphology measurements were initiated on March 29, 2001, with a baseline survey. During the above-mentioned period of oceanographic data collection, dense topographic surveying of the stretch of beach from the Grays Harbor North Jetty in Ocean Shores, Wash., to 4-km north of the North Jetty was performed weekly. Offshore of this 4-km section of beach, monthly surveys of nearshore bathymetry were collected along twenty 200-m-spaced transects. Beach profiles were also typically collected monthly along 6 cross-shore beach profile lines spaced at 1 km intervals from 4-km north of the North Jetty to approximately 10 km north of the North Jetty. A final survey was performed one month following the completion of the processes experiment.

It should be noted that these measurements supplement data collected in an earlier experiment conducted in autumn 1999 (Gelfenbaum and others, 2000). The objectives of the autumn measurements were (1) to calibrate and verify numerical models of wave transformation (primarily refraction and shoaling) and (2) to provide information about bottom sediment size, waves, currents, and suspended-sediment concentrations for use in calculations of sediment transport. The autumn data collection period included a wide range of wave conditions and several large storms.

This report contains descriptions of the instruments used during the experiment, the calibrations associated with the instruments, and the setup of the instruments during

the experiment. The discussion of the data recovery includes plots of most of the data collected during the experiment, detailed lists of known data problems, preliminary processing, and a discussion of preliminary results. The data from the experiment are provided on the accompanying DVDs, as is a digital copy of this report, pressure sensor calibration files, and several algorithms designed for processing the data.

Several general conclusions can be made from the data:

- (1) Temperature and density are inversely related in the spring-time CTD profiles, warmer fresher water overlies colder denser water, which is a reversal from the profiles collected during winter 1999 where the deeper, denser water was warmer than the overlying, fresher water.
- (2) Stratification occurs during the milder summer wind conditions.
- (3) The stratified water column allowed for the decoupling of velocities at the top of the water column from those at the bottom. Near-bottom currents tended to flow northward (and off-shore at two of the three sites monitored), where as surface currents tended to flow southward and onshore.
- (4) The threshold for sediment movement, based on analysis of the grain roughness Shields parameter, was exceeded throughout the experiment, at least at the two inshore sites.
- (5) The shoreline prograded 10 to 20 m. This change was dominated by onshore bar migration, trough infilling, and sub-aerial sediment accumulation.
- (6) Virtually all morphological change occurred between the -6 and +3 m (mean lower low water - MLLW) contours.

Data and conclusions provided in this report are preliminary and may contain errors that remained undetected in routine quality-control checks. Future analysis may modify some values. Therefore, these data are provided to and accepted by the user with any accompanying faults and defects. Any person or entity that relies upon information generated by or obtained herein does so at their own risk.

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INTRODUCTION

1.1 Southwest Washington Coastal Erosion Study

The Southwest Washington Coastal Erosion Study (SWCES) is a multi-year multidisciplinary investigation of the Columbia River littoral cell (CRLC), a 165-km-long coastal region between Tillamook Head, Oregon, and Point Grenville, Washington. The study is cosponsored by the U.S. Geological Survey (USGS) and the Washington State Department of Ecology (WSDOE). The study was initiated in 1996 in response to several erosion crises on a coast that had been prograding for most of the 20th century (Gelfenbaum and others, 1997; Kaminsky and others, 1997). The goals of the study were to improve scientific understanding of coastal morphodynamics and sedimentary processes, to determine natural and anthropogenic influences on the littoral system, and to provide information and predictions of coastal change on scales suitable for management of coastal resources.

1.2 Grays Harbor Wave Refraction Experiment, Autumn 1999

The Grays Harbor Wave Refraction Experiment, conducted in autumn 1999, was designed to provide information that can be used to improve predictive numerical modeling of shoreline change. The objectives of the Grays Harbor Wave Refraction Experiment were:

- (1) Provide data to calibrate and verify numerical models of wave transformation (primarily refraction and shoaling) near the entrance to Grays Harbor, and
- (2) Provide measurements of bottom sediment size, waves, currents, and suspended-sediment concentrations for calculations of sediment transport.

The experiment was conducted from October to December, 1999, because analysis of historical data indicated that wave height and direction of wave approach was especially variable as North Pacific weather patterns shifted from autumn to winter (Tillotson and Komar, 1997). A deployment at this time provided a range of wave conditions with which to calibrate wave transformation models. Measurements were made using six instrumented tripods deployed near the entrance to Grays Harbor. Mounted on the tripods were sensors for measuring wave- and tide-induced pressure elevations, currents, and suspended sediments. These instruments included pressure transducers, single-point, three-axis acoustic Doppler velocimeters (ADV), upward-looking acoustic Doppler profilers (ADPs), and optical backscatter sensors (OBS).

In addition to the instrumented tripods, bottom sediment grab samples were taken at several locations, including all tripod sites, and profiles of water conductivity, temperature, and depth (CTD) were collected. The grab samples were obtained for calibration of the OBS deployed on the tripods and to aid in interpretation of acoustic backscatter data from previously collected side-scan sonar and multi-beam surveys. The CTD profiles were collected to aid in the interpretation of the velocity profiles.

Data collection methods, preliminary results, and the collected data are available in the *Grays Harbor Wave Refraction Experiment 1999: Data Report*, U.S. Geological Survey Open-File Report 00-404, by Gelfenbaum and others (2000). This report can be accessed at <http://pubs.usgs.gov/of/2000/of00-404/>.

1.3 Grays Harbor Sediment Transport Experiment, Spring 2001

The Spring 2001 Grays Harbor Sediment Transport Experiment was designed to extend and complement the autumn 1999 experiment and provide wave, current, and sediment-transport measurements during the transition from winter to summer conditions. The experiment period

included the beginning of the summer upwelling season, when winds are predominantly from the northwest and the storm tracks shift north. Waves are typically smaller in summer, and the beach tends to accrete. Timing was also intended to overlap with experiments conducted by the U.S. Army Corps of Engineers (USACE) and their contractors.

Many of the same instruments deployed during the autumn 1999 experiment were redeployed in spring 2001, and four of the measurement locations were reoccupied. New sites were chosen to provide more detailed information about incident waves and currents north of the entrance to the harbor. Tripods were deployed at a shallow (~9-m MSL) inner shelf location off North Beach to measure conditions just outside the surf zone. Bottom grab samples and conductivity, temperature, and depth (CTD) profiles were collected, and repetitive bathymetric surveying and beach profiling were conducted on North Beach to study morphological adjustment of the shoreface to seasonally changing conditions and to estimate net sand transport into (or out of) the study area. These data will be used to:

- (1) Infer circulation and sediment-transport patterns on the northern flank of the ebb-tidal delta,
- (2) Develop and validate wave, current, and sediment-transport models near the entrance to Grays Harbor, and
- (3) Provide boundary conditions for littoral transport calculations.

1.4 Overview of This Report

This report describes data collected during the Spring 2001 Grays Harbor Sediment Transport Experiment, and provides additional information needed to interpret the data. Two DVDs accompany this report; both contain documentation in html format that assist the user in navigating through the data.

DVD01 contains a digital version of this report in .pdf format, raw Aquatec acoustic backscatter (ABS) data in .zip format, Sonar data files in .avi format, and coastal processes and morphology data in ASCII format. ASCII data files are provided in .zip format; bundled coastal processes ASCII files are separated by deployment and instrument; bundled morphology ASCII files are separated into monthly data collection efforts containing the beach profiles collected (or extracted from the surface map) at that time; weekly surface maps are also bundled together.

DVD02 contains a digital version of this report in .pdf format, the binary data files collected by the SonTek instrumentation, calibration files for the pressure sensors, and Matlab m-files for loading the ABS data into Matlab and cleaning-up the optical backscatter (OBS) burst time-series data.

DATA COLLECTION METHODS

2.1 Experiment Overview

The spring 2001 experiment consisted of two parts—(1) a coastal processes experiment and (2) beach morphology monitoring program. Figure 1 summarizes the types of data and time periods of data collection associated with this experiment.

The processes experiment consisted of six tripods that were deployed in May 2001 on and around the entrance to Grays Harbor, Washington, (fig. 2) to measure waves, tides, currents, and suspended-sediment concentration. Tripod locations were designated according to their relative location along the coast—(N)orth, (M)iddle, or (S)outh—and their relative depth—(D)eep, (S)hallow, or (I)nshore. Thus ND refers to the northernmost, deeper location, MS refers to the middle, shallower location, and

MI refers to the middle inshore location. There were two tripods at the middle inshore site, designated MIA and MIB. Tripod instrumentation is described in section 2.4.1.

The tripods were initially deployed May 4, 2001 (all dates and times are reported in Greenwich Mean Time, GMT). Turnaround and retrieval dates are shown in tables 1 and 2. The fishing vessel (F/V) *Tricia Rae* from Tokeland, Washington, was used throughout the experiment for tripod deployment and retrieval and grab sampling and CTD collection at the tripod sites. Tripod deployment and sample locations were determined using an eight-channel Furuno Navigator differential Global Positioning System (DGPS), which used the differential signal from U.S. Coast Guard beacons. Geographic positions are north latitude and west longitude, referenced to the North American Datum of 1983 (NAD83). Coordinates are also reported in Washington State Plane (South Zone) meters. The approximate depths reported in tables 1, 2, and 4 were collected from a fathometer mounted on the ship and were recorded at the time of the deployment, retrieval, or sample collection without regard for tidal stage or datum. More accurate water depths can be retrieved from the pressure data collected at each site.

To better understand the area being studied and the measurements that were collected it is important to understand the regional setting. It is not the intention of this report to summarize all of the data that has been collected in this area, but some are presented to provide background information with which to view the spring 2001 measurements. The Grays Harbor directional wave buoy No. 03601 is maintained by the Coastal Data Information Program (CDIP) and is moored in 42-m water depth offshore of the southernmost site (SD) (fig. 2). Data collected by the CDIP buoy during the time of the experiment are plotted in fig. 5 and can be downloaded from the CDIP web site (<http://cdip.ucsd.edu/>). Meteorological data collected by the USACE during the period from May through June, 2001, using a RM Young 27600 meteorologic station are also shown in fig. 5. The station, designated M1, was placed on the U.S. Coast Guard watch tower in Westport, Wash. (46° 54' 15.83" N, 123° 07' 16.27" W within 15 feet (4.6 m) horizontal) (fig. 2). Wind data were collected at a height of 108 ft ± 2 ft (32.9 m ± 0.6 m) referenced to the North American Vertical Datum of 1988 (NAVD88) or 90 feet ± 2ft (27.4 m ± 0.6 m) above the base of the tower. However, the base of the tower is behind a sand berm that is probably 10 to 15ft (3.0-4.6 m) higher than the tower base, which is 16.8 ft (5.1 m) NAVD88. Bathymetric data (figs. 2, 3, and 4) and multibeam backscatter data (Gelfenbaum and others, 2000) (fig. 3) are presented, as well as orthophoto mosaics (figs. 3 and 4) and their associated shoreline delineation (fig. 3).

In conjunction with the coastal processes measurements, a section of beach within the study area was regularly surveyed in order to document seasonal morphological changes over the nearshore (fig. 4). Beach morphology measurements were initiated on March 29, 2001, with a baseline survey (table 3). Throughout the period of coastal processes data collection, dense topographic surveying of the stretch of beach from the Grays Harbor North Jetty in Ocean Shores, Wash., to 4-km north of the North Jetty was performed weekly. Offshore of this 4-km section of beach, monthly surveys of nearshore bathymetry were collected along twenty 200-m-spaced transects. Beach profiles were also typically collected monthly along six cross-shore beach profile lines spaced at 1 km intervals from 4 km north of the North Jetty to approximately 10 km north of the North Jetty. The nearshore bathymetric components of these transects were often collected as well. A final survey was performed one month following the completion of the processes experiment.

In the USGS Coastal and Marine Geology Program InfoBank, this data collection involved three field activity IDs—T-1-01-WA, W-1-01-WA, and W-2-01-WA. Metadata for the respective field activities are provided at the URLs:

- <http://walrus.wr.usgs.gov/infobank/t/t101wa/html/t-1-01-wa.meta.html>,
- <http://walrus.wr.usgs.gov/infobank/w/w101wa/html/w-1-01-wa.meta.html>, and
- <http://walrus.wr.usgs.gov/infobank/w/w201wa/html/w-2-01-wa.meta.html>.

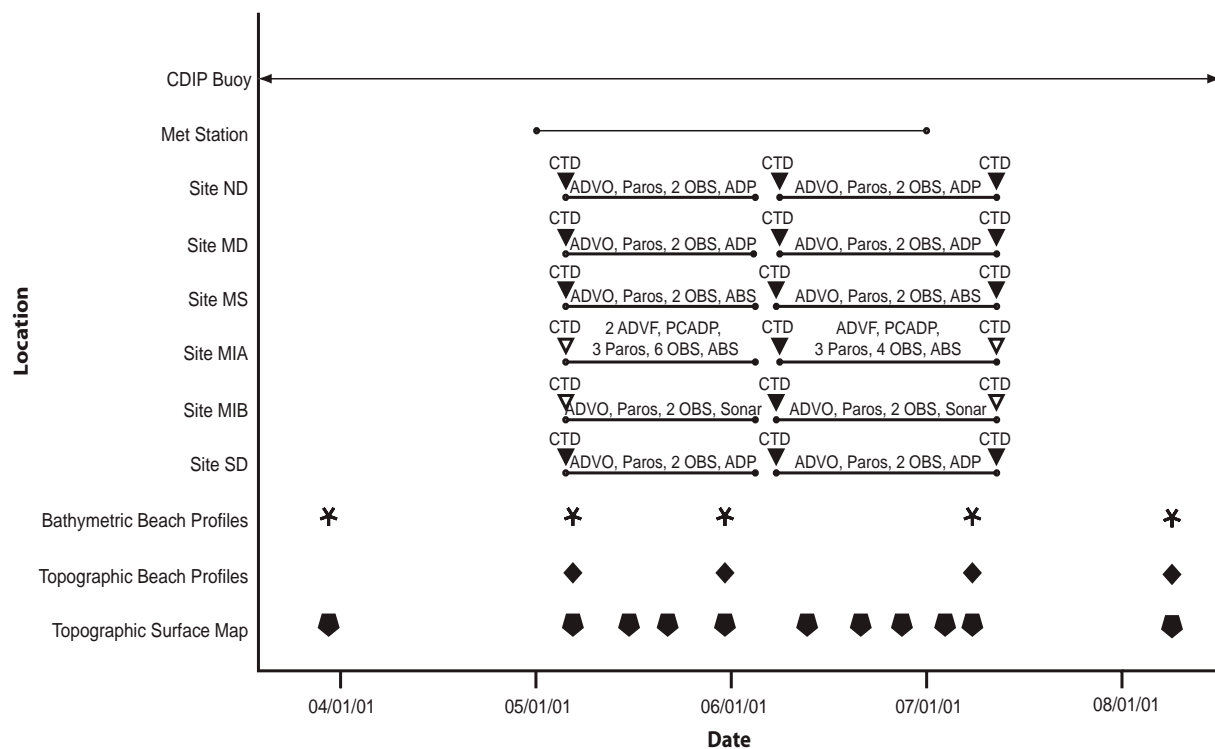


Figure 1. Timeline showing the periods of oceanographic and morphologic data collection. Open triangles at MIA and MIB signify times where, owing to the close proximity of the tripods, one conductivity-temperature-depth (CTD) cast, designated MI, was taken as representative of the two locations. (CDIP—Coastal Data Information Program; ADV—acoustic Doppler velocimeter, Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse coherent acoustic Doppler profiler).

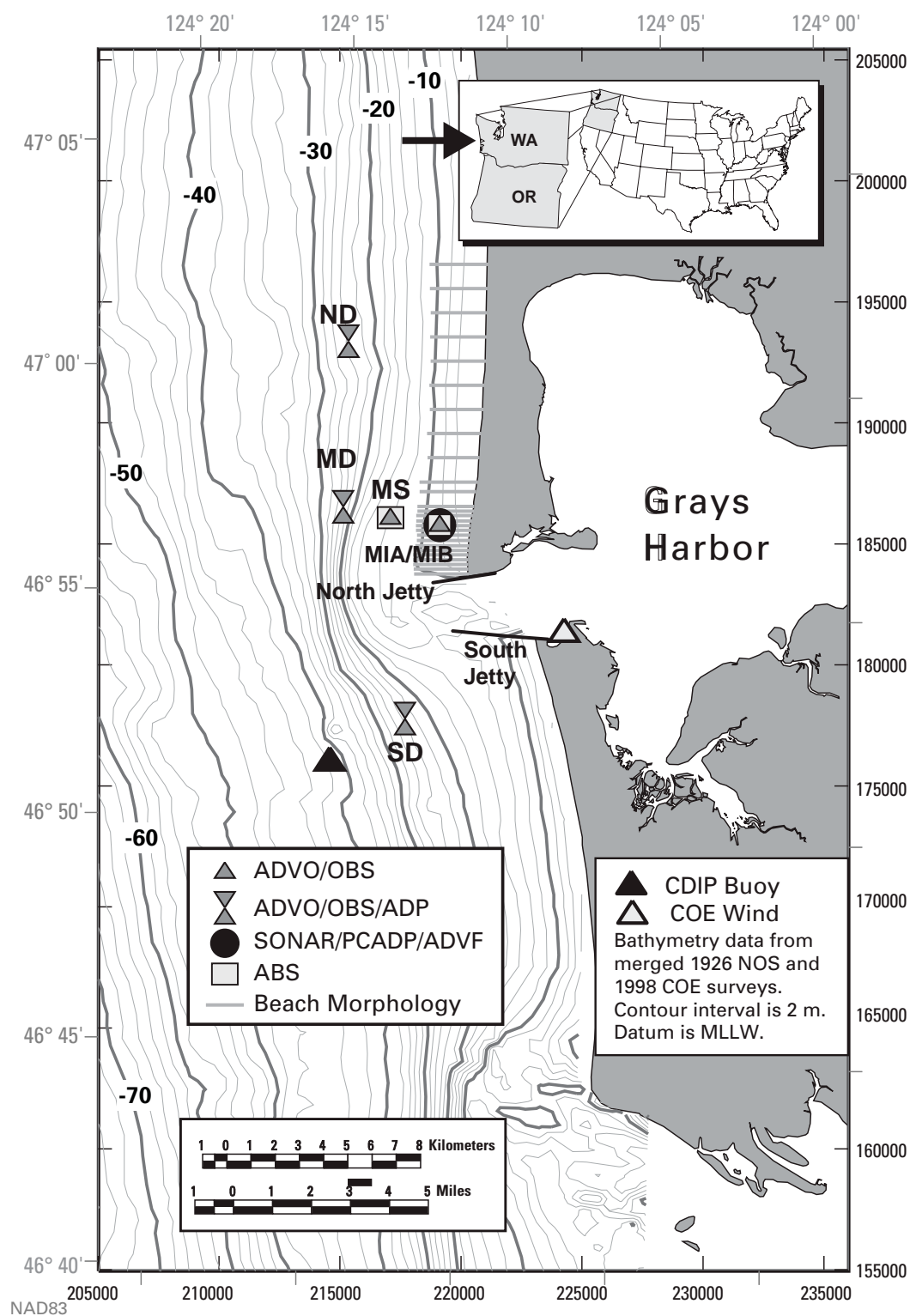


Figure 2. Chart of the study area near Grays Harbor, Washington, showing sites where U.S. Geological Survey tripods were deployed and areas of morphologic data collection during the Spring 2001 Grays Harbor Sediment Transport Experiment. Also shown are the locations of the Grays Harbor directional wave buoy (Coastal Data Information Program—CDIP—buoy No. 03601) and the U.S. Army Corps of Engineers (COE) meteorological data station (M1) located at the U.S. Coast Guard watch tower in Westport, Wash. (ADV—acoustic Doppler velocimeter; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler; NAD—North American Datum; NOS—National Ocean Service).

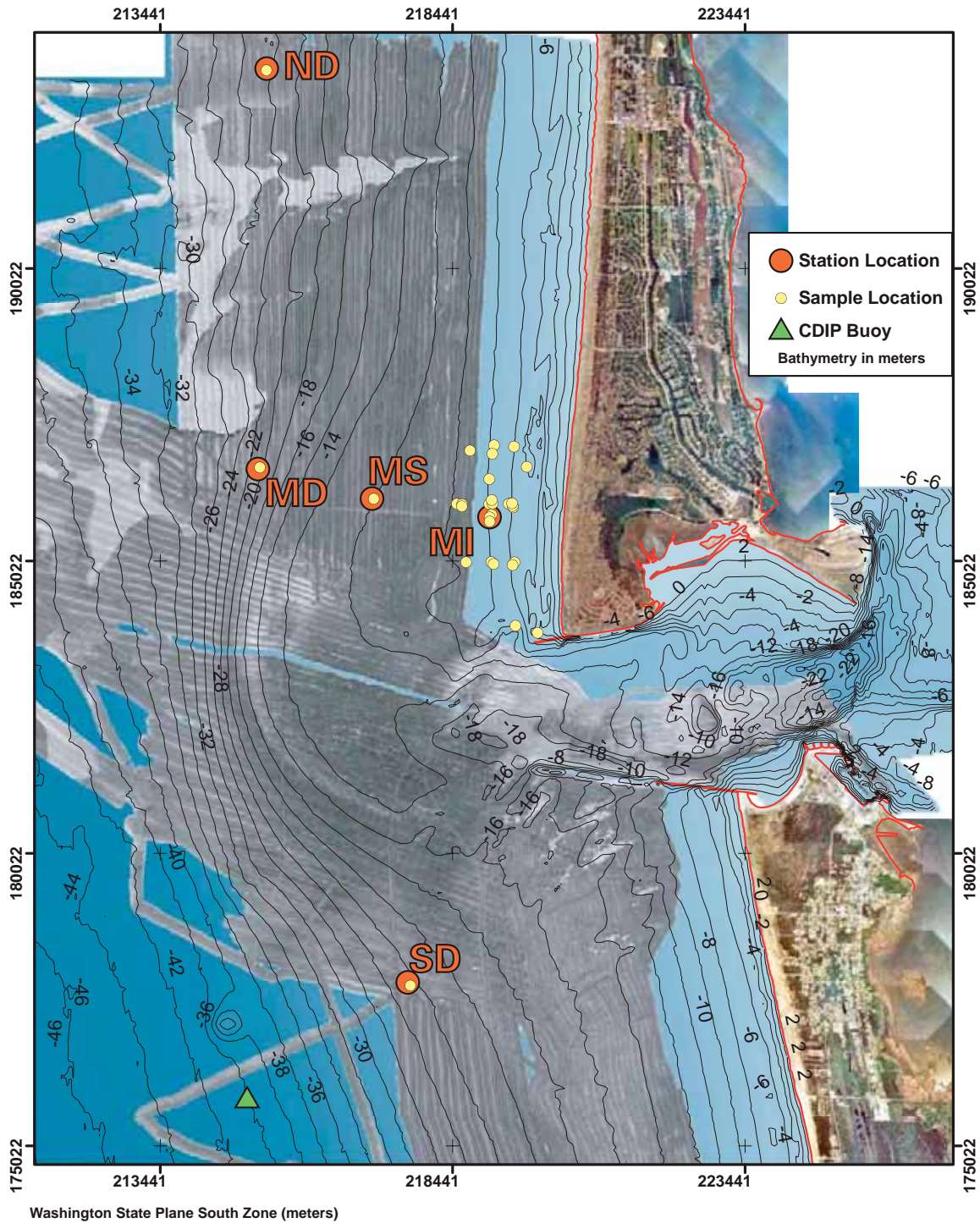


Figure 3. Bathymetric map of Grays Harbor, Wash., study area overlain with multibeam backscatter data (Gelfenbaum and others, 2000). Surface sediment samples were collected throughout the study area. The orthophoto mosaics and their associated shoreline delineation (average high water line) were created by the U.S. Geological Survey–Washington State Department of Ecology Coastal Erosion Study from Washington State Department of Natural Resources aerial photography, mission SWC-99 flown on May 26, 1999. (CDIP—Coastal Data Information Program).

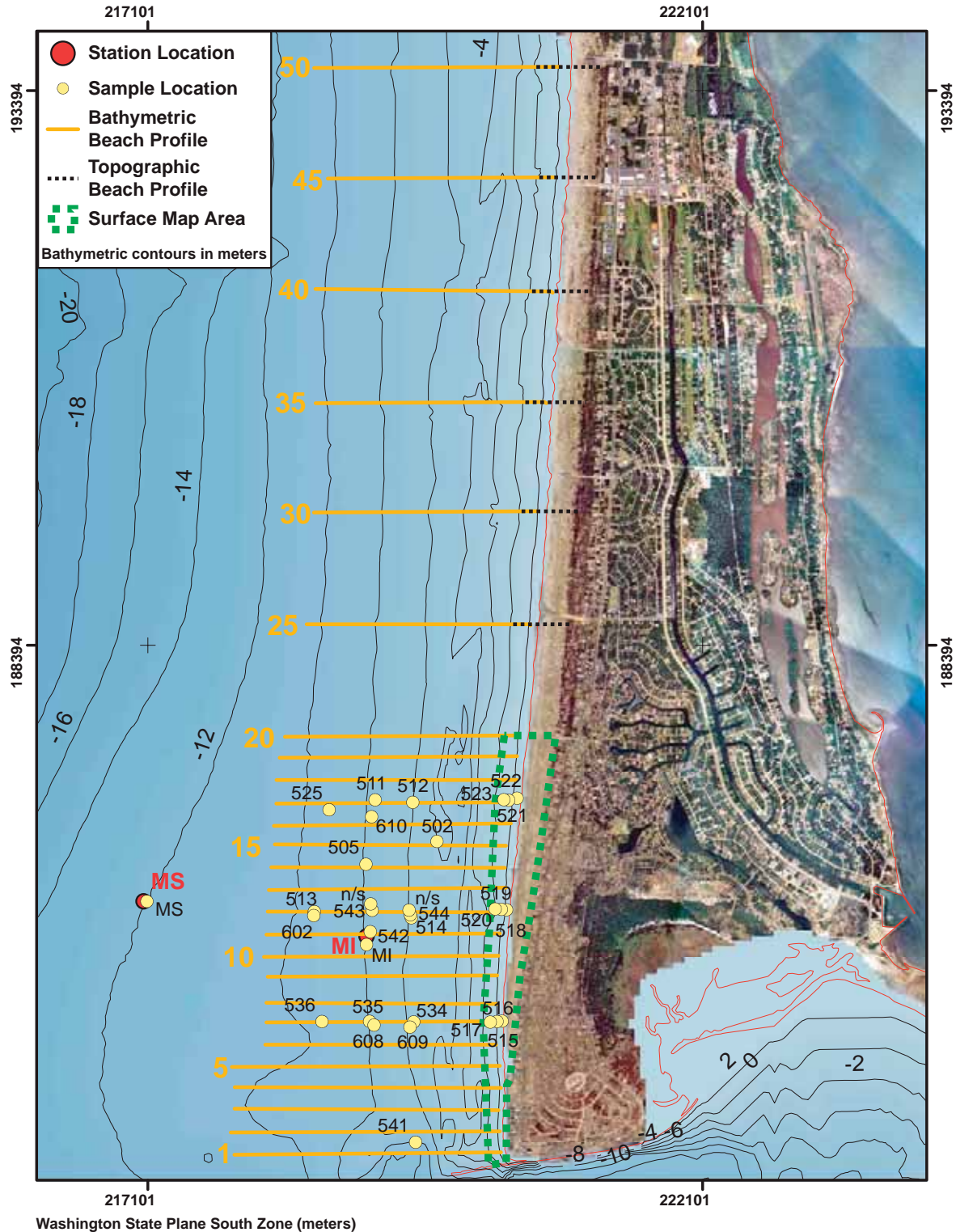


Figure 4. Map zoomed in to show the locations of the sediment samples taken in conjunction with the collection of nearshore beach morphology data in March and May, 2001. The green-dashed box outlines the area where surface maps were collected. The locations of bathymetric and topographic beach profiles are shown respectively by orange and black-dashed lines. The ortho-photo mosaics and their associated shoreline delineation (average high water line) were created by the U.S. Geological Survey–Washington State Department of Ecology Coastal Erosion Study from Washington State Department of Natural Resources aerial photography, mission SWC-99 flown on May 26, 1999.

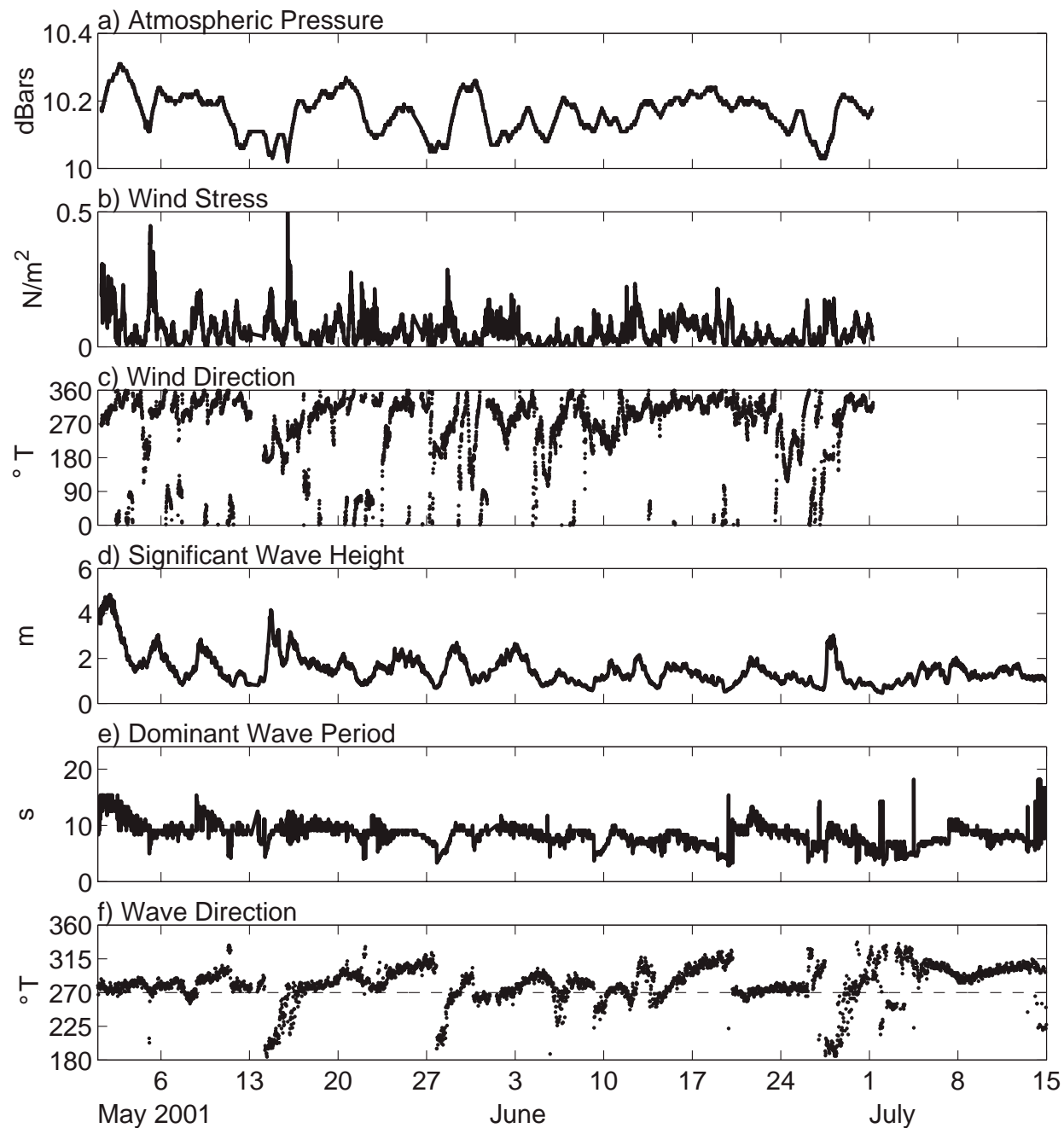


Figure 5. Time series of data collected by the Grays Harbor, Wash., Coastal Data Information Program buoy and the U.S. Army Corps of Engineers meteorological station at Westport, Wash., during the time of the Spring 2001 Grays Harbor Experiment. Wind stress was calculated according to Large and Pond (1981). $^{\circ}T$ —degrees from true north.

Table 1. Summary of the deployment and retrieval times and deployment locations for Deployment 1.

[Times are reported in GMT. The location and depth of the Coastal Data Information Program (CDIP) wave buoy are also presented.]

Site	North Latitude	West Longitude	Approx. Depth (m)	Washington State Plane, South Zone		Deployment		Recovery	
				Easting (m)	Northing (m)	Date	Time	Date	Time
ND	47° 00.77'	124° 14.78'	25	215265.3	193438.5	05/04/01	1538	06/05/01	2025
MD	46° 57.07'	124° 14.64'	24	215115.2	186593.1	05/04/01	2038	06/05/01	1948
MS	46° 56.85'	124° 13.08'	13	217065.8	186085.7	05/04/01	2005	06/05/01	1932
MIA	46° 56.70'	124° 11.49'	9	219073.0	185715.5	05/04/01	1408	06/05/01	1557
MIB	46° 56.73'	124° 11.49'	9	219074.9	185769.1	05/04/01	1418	06/05/01	1607
SD	46° 52.41'	124° 12.30'	24	217676.0	177813.8	05/04/01	2141	06/05/01	1701
CDIP Buoy	46° 51.40'	124° 14.68'	41	214572.1	176094.5				

Table 2. Summary of the deployment and retrieval times and deployment locations for Deployment 2.

[Times are reported in GMT.]

Site	North Latitude	West Longitude	Approx. Depth (m)	Washington State Plane, South Zone		Deployment		Recovery	
				Easting (m)	Northing (m)	Date	Time	Date	Time
ND	47° 00.77'	124° 14.76'	25	215285.2	193442.3	06/08/01	0314	07/11/01	1625
MD	46° 57.05'	124° 14.68'	24	215065.4	186557.8	06/08/01	0228	07/11/01	1718
MS	46° 56.85'	124° 13.08'	13	217066.3	186077.7	06/07/01	2142	07/11/01	2105
MIA	46° 56.72'	124° 11.48'	9	219082.5	185740.9	06/08/01	0158	07/11/01	2023
MIB	46° 56.74'	124° 11.49'	9	219073.6	185779.4	06/07/01	2158	07/11/01	2029
SD	46° 52.41'	124° 12.36'	24	217594.1	177831.9	06/07/01	2053	07/11/02	1817

Table 3. Summary of beach morphology data collection.

Date	Data Type	Coverage
03/29/01	Bathymetric Beach Profiles	Lines 5-20
03/29/01	Topographic Surface Map	Surface Map
05/06/01	Bathymetric Beach Profiles	Lines 1-20, 25, 30, 35, 40, 45, 50
05/06/01	Topographic Beach Profiles	Lines 25, 30, 35, 40, 45, 50
05/06/01	Topographic Surface Map	Surface Map
05/15/01	Topographic Surface Map	Surface Map
05/21/01	Topographic Surface Map	Surface Map
05/30/01	Bathymetric Beach Profiles	Lines 1-20, 25, 30, 35, 40, 45, 50
05/30/01	Topographic Beach Profiles	Lines 25, 30, 35, 40, 45, 50
05/30/01	Topographic Surface Map	Surface Map
06/12/01	Topographic Surface Map	Surface Map
06/20/01	Topographic Surface Map	Surface Map
06/26/01	Topographic Surface Map	Surface Map
07/03/01	Topographic Surface Map	Surface Map
07/07/01	Bathymetric Beach Profiles	Lines 1-20, 25, 30, 35, 40, 45, 50
07/07/01	Topographic Beach Profiles	Lines 25, 30, 35, 40, 45, 50
07/07/01	Topographic Surface Map	Surface Map
08/06/01	Bathymetric Beach Profiles	Lines 1-20, 25, 30, 35, 40, 45, 50
08/06/01	Topographic Beach Profiles	Lines 25, 30, 35, 40, 45, 50
08/06/01	Topographic Surface Map	Surface Map

2.2 Surface Sediment Samples

Grab samples of surface sediments were obtained using a Van Veen grab sampler over the sides of the F/V *Tricia Rae* (TR; table 4) and the Coastal Profiling System (CPS; table 5). Samples were obtained from each of the tripod deployment sites and several locations inshore (figs. 3 and 4). Surface beach sediment samples were collected on May 7, 2001 (table 6).

Table 4. Visual and location descriptions of the surface sediment samples collected using a Van Veen grab sampler aboard the F/V *Tricia Rae*.

Site	Latitude	Longitude	Washington State Plane, South Zone		Date	Approx. Depth (m)	Visual Description and Comments
			Easting (m)	Northing (m)			
ND	47° 00.75'	124° 14.78'	215256.1	193414.3	05/04/01	25	fine greyish-green sand, a lot of worms, 2mm shell.
MD	46° 57.09'	124° 14.62'	215145.3	186623.3	05/04/01	24	fine greyish-green sand, many worms, storm layer visible (woody pieces and larger (~1mm) sand grains).
MS	46° 56.85'	124° 13.06'	217093.4	186087.2	05/04/01	13	fine greyish-green sand, 1.5-3 inch sand dollars.
MI	46° 56.75'	124° 11.47'	219106.5	185813.6	05/04/01	9	fine greyish-green sand, 3 inch sand dollar.
SD	46° 52.38'	124° 12.26'	217718.5	177764.8	05/04/01	24	fine greyish-green sand with some sand dollar fragments, extreme amount of sand dollars.

Table 5. Visual and location descriptions of the surface sediment samples collected using a Van Veen grab sampler from aboard the Coastal Profiling System (CPS).

Sample No.	Latitude	Longitude	Washington State Plane, South Zone		Date	Approx. Depth (m)	Visual Description and Comments
			Easting (m)	Northing (m)			
610	46° 57.31'	124° 11.50'	219119.1	186849.0	03/30/01	8	Line 16 - fine greyish-green sand.
502	46° 57.21'	124° 11.02'	219706.9	186626.7	03/30/01	5	Line 15 - fine greyish-green sand.
505	46° 57.09'	124° 11.52'	219068.6	186421.0	03/30/01	8	Line 14 - fine greyish-green sand.
514	46° 56.83'	124° 11.18'	219475.8	185937.7	05/06/01	6	Line 12 - fine greyish-green sand.
544	46° 56.85'	124° 11.18'	219467.9	185964.6	05/06/01	6	Line 12 - fine greyish-green sand.
543	46° 56.85'	124° 11.47'	219123.3	186005.3	05/06/01	8	Line 12 - fine greyish-green sand.
542	46° 56.68'	124° 11.48'	219072.8	185696.7	05/06/01	8	near MIB - fine greyish-green sand.
513	46° 56.83'	124° 11.87'	218603.1	185994.4	05/06/01	10	Line 12 - fine greyish-green sand.
541	46° 55.73'	124° 11.07'	219515.5	183915.9	05/06/01	6	Line 1 - fine greyish-green sand.
512	46° 57.40'	124° 11.22'	219489.3	186979.0	05/07/01	6	Line 17 - fine greyish-green sand.
511	46° 57.40'	124° 11.48'	219150.0	187000.4	05/07/01	8	Line 17 - fine greyish-green sand.
525	46° 57.33'	124° 11.80'	218736.3	186910.9	05/07/01	10	Line 17 - fine greyish-green sand.
536	46° 56.18'	124° 11.78'	218671.9	185002.9	05/07/01	10	Line 7 - fine greyish-green sand.
535	46° 56.19'	124° 11.43'	219100.8	185004.6	05/07/01	8	Line 7 - fine greyish-green sand.
534	46° 56.33'	124° 11.13'	219499.1	185000.1	05/07/01	6	Line 7 - fine greyish-green sand.
609	46° 56.30'	124° 11.15'	219464.7	184953.7	07/08/01	6	Line 7 - fine greyish-green sand.
608	46° 56.30'	124° 11.42'	219140.8	184972.0	07/08/01	8	Line 7 - fine greyish-green sand.
602	46° 56.82'	124° 11.87'	218598.2	185957.9	07/08/01	10	Line 12 - fine greyish-green sand.
no sample	46° 56.88'	124° 11.47'	219110.6	186063.1	07/08/01	8	Line 12 - no sediment recovered, sand dollars only.
no sample	46° 56.87'	124° 11.21'	219456.5	186007.7	07/08/01	6	Line 12 - no sediment recovered, sand dollars only.

Table 6. Visual and location descriptions of the surface sediment samples collected during the CLAMMER (Coastal All-terrain 15 Monitoring and Erosion Research vehicle) survey on May 7, 2001.

Sample No.	Latitude	Longitude	Washington State Plane, South Zone		Date	Approx. Elevation (m)	Visual Description and Comments
			Easting (m)	Northing (m)			
515	47° 14.43'	124° 39.73'	220294.0	185006.4	05/07/01	4	Line 7 - fine greyish-green sand.
516	47° 14.40'	124° 39.73'	220249.3	185003.4	05/07/01	2	Line 7 - fine greyish-green sand.
517	47° 14.37'	124° 39.73'	220187.7	184998.9	05/07/01	0	Line 7 - fine greyish-green sand.
518	47° 14.48'	124° 38.95'	220335.0	186010.7	05/07/01	4	Line 12 - fine greyish-green sand.
519	47° 14.45'	124° 38.93'	220287.8	186013.9	05/07/01	2	Line 12 - fine greyish-green sand.
520	47° 14.42'	124° 38.93'	220231.7	186017.0	05/07/01	0	Line 12 - fine greyish-green sand.
521	47° 14.55'	124° 38.15'	220429.0	187016.7	05/07/01	4	Line 17 - fine greyish-green sand.
522	47° 14.52'	124° 38.02'	220353.1	186997.2	05/07/01	2	Line 17 - fine greyish-green sand.
523	47° 14.48'	124° 38.02'	220309.2	187002.7	05/07/01	0	Line 17 - fine greyish-green sand.

2.3 Conductivity-Temperature-Depth (CTD) Profiles

Profiles of conductivity, temperature, and depth (CTD) were measured with a Sea-Bird SBE 19 SEACAT at each site at the beginning of each deployment of the tripod and upon retrieving the tripod at the end of Deployment 2 (table 7).

The CTD sensor set-up was as described in the SBE 19 SEACAT manual, except that an external Paros pressure sensor was mounted at a level approximately in the middle of the conductivity tube, approximately 8 cm higher than the thermistor. There was no pump on the conductivity sensor.

Table 7. Locations and times of the conductivity-temperature-depth casts.

Site	North Latitude	West Longitude	Washington State Plane South Zone		Date	Time (GMT)
			Easting (m)	Northing (m)		
ND	47° 00.73'	124° 14.77'	215171.5	193366.0	05/04/01	1542
MD	46° 57.11'	124° 14.60'	217102.8	186651.9	05/04/01	2041
MS	46° 56.86'	124° 13.06'	219132.2	186107.2	05/04/01	2019
MI	46° 56.73'	124° 11.45'	217696.0	185762.4	05/04/01	1446
SD	46° 52.40'	124° 12.28'	215314.1	177804.2	05/04/01	2056
ND	47° 00.73'	124° 14.74'	215037.6	193367.5	06/08/01	0317
MD	46° 57.02'	124° 14.70'	217037.6	186493.7	06/08/01	0231
MS	46° 56.82'	124° 13.10'	219093.2	186028.2	06/07/01	2145
MIA	46° 56.70'	124° 11.47'	219083.9	185709.9	06/08/01	0201
MIB	46° 56.70'	124° 11.48'	217642.2	185710.5	06/07/01	2201
SD	46° 52.38'	124° 12.32'	215291.5	177765.6	06/07/01	2057
ND	47° 00.75'	124° 14.75'	215066.5	193395.0	07/11/01	1639
MD	46° 57.08'	124° 14.68'	217101.4	186604.6	07/11/01	1726
MS	46° 56.86'	124° 13.06'	219073.3	186111.3	07/11/01	2130
MI	46° 56.71'	124° 11.49'	217616.6	185730.7	07/11/01	2037
SD	46° 52.43'	124° 12.35'	215171.5	177854.8	07/11/01	1824

2.4 Coastal Processes Measurements

2.4.1 Instrumentation

Acoustic releases and secondary-retrieval buoy systems were deployed at the three deepwater sites. Each tripod was deployed with an acoustic pinger to aid in the recovery of the tripod should the primary or secondary retrieval systems fail. These systems were not utilized and will not be discussed in detail in this report.

2.4.1.1 SonTek Acoustic Doppler Ocean Velocimeter (ADVO) Hydra Systems

Each SonTek acoustic Doppler Ocean velocimeter Hydra system (ADVO Hydra) incorporated an ADVOcean acoustic Doppler velocimeter (ADVO), a serial Paroscientific digiquartz pressure sensor (Paros), and two optical backscatter sensors (OBS) manufactured by D&A Instruments. Serial numbers and sampling parameters are listed in table 8.

The ADVO is a 5-MHz single-point current meter that measures three components (for example, east, north, and up) of velocity in a small, undisturbed volume approximately 16 cm from the transmitter. Each ADVO also measures temperature and compass heading, pitch, and roll. All data were recorded on an internal data logger housed in a separate pressure housing, and power was supplied from an external battery canister.

The sampling scheme for the ADVO Hydra systems was identical for each system and each deployment. The ADVO Hydra systems sampled continuously for 20 minutes and recorded at 2 Hz (2,400 samples) every hour. The bursts were centered on the hour (that is, they began at HH:50:00).

The effects of biofouling are apparent in the OBS records collected by all the ADVO Hydra systems during Deployment 1 with the exception of OBS 2 at Site SD; the ADVO Hydra system OBS records from Sites MD, MS, and MIB were affected by biofouling during Deployment 2. The compass in the ADVO deployed at Site ND was damaged either before the first deployment or shortly after going in the water. The heading, pitch, and roll are all slightly off for both deployments. Therefore, the velocities, particularly vertical velocity, for both deployments should be treated with caution.

Interference at radio frequencies can distort OBS signals when a pair of OBS are mounted close together (within ~2 m) and logged on the same Hydra system, as was the case during this experiment. The result is a sinusoidal oscillation superimposed on the instantaneous burst measurements. The burst-mean values are unaffected by this problem, which is discussed in more detail in appendix F.

Table 8.—SonTek acoustic Doppler velocimeter Ocean (ADVO) Hydra system serial numbers (S/N) and sampling parameters.

[(Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor)]

Site	Inst Type	Deployment No.	ADVOcean and Data Logger S/N	Paros S/N	OBS 1 S/N	OBS 2 S/N	Sampling Rate (Hz)	Burst Interval (s)	Samples Per Burst	Burst Length (s)	Coordinate System
ND	ADVO	1	B45	66890	795	796	2	3600	2400	1200	XYZ
		2	B45	66890	795	796	2	3600	2400	1200	XYZ
MD	ADVO	1	B51	69130	1242	1135	2	3600	2400	1200	XYZ
		2	B51	69130	1242	1135	2	3600	2400	1200	XYZ
MS	ADVO	1	B167/B158	69128	928	1104	2	3600	2400	1200	XYZ
		2	B158	69128	928	1104	2	3600	2400	1200	XYZ
MIB	ADVO	1	B59	69181	1244	1429	2	3600	2400	1200	XYZ
		2	B59	69181	1244	1429	2	3600	2400	1200	XYZ
SD	ADVO	1	B52	69180	1243	1428	2	3600	2400	1200	XYZ
		2	B52	69180	1243	1428	2	3600	2400	1200	XYZ

2.4.1.2 SonTek Acoustic Doppler Field Velocimeter (ADVF) Hydra Systems

Each SonTek acoustic Doppler Field velocimeter Hydra system (ADVF Hydra) incorporated an ADVField acoustic Doppler velocimeter (ADVF), a frequency Paroscientific digiquartz pressure sensor (Paros), and two optical backscatter sensors (OBS) manufactured by D & A Instruments. Serial numbers and sampling parameters are listed in table 9.

The ADVF is a high-frequency (10 MHz) single-point current meter that measures three components (for example, east, north, and up) of velocity in a small, undisturbed volume approximately 10 cm from the transmitter. The instrument's ability to measure velocities at a high frequency (up to 25 Hz) allows for turbulence measurements. Each ADVF also measures temperature and compass heading, pitch, and roll. All data were recorded on an internal data logger housed in a pressure housing that also housed the battery power supply. Frequency Paroscientific digiquartz pressure sensors require a calibration file; the filename for each calibration is also listed in table 9, and the calibration files are provided on the accompanying DVD, DVD02.

During Deployment 1, the ADVF Hydra systems were set to sample continuously for 20 minutes and record velocities at 20 Hz (24,000 samples) and additional data at 10 Hz (12,000 samples) every 2 hours. One of the ADVF, S/N 231, was damaged during the turnaround, so the sampling scheme was changed for ADVF S/N 244 during Deployment 2. Additionally, the pressure sensor deployed with ADVF S/N 244, S/N 60006, was replaced with S/N 60005, which had originally been deployed with ADVF S/N 231. The ADVF Hydra system, during Deployment 2, sampled continuously for 20 minutes at 10 Hz (12000 samples) every hour to provide additional data for verification of the pulse-coherent acoustic Doppler velocimeter. The bursts, during both deployments, were centered on the hour (that is, they began at HH:50:00).

ADVF S/N 231 was synchronized with, and master to, ADVF S/N 244 and acoustic backscatter system (ABS) No. 1 during Deployment 1. The trigger from ADVF S/N 231 was transmitted through a cable connected to both the ABS and ADVF S/N 244. The receipt of the trigger initiated data collection on the respective instruments.

Problems with a firmware upgrade to the ADVFs before deployment caused the ADVF Hydra systems to not record pressure correctly during either deployment.

The OBS measurements collected by the ADVF Hydra systems were affected by both biofouling and the interference problem discussed previously and in appendix F.

Table 9. SonTek acoustic Doppler velocimeter Field (ADVF) Hydra system serial numbers (S/Ns) and sampling parameters.

[(Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor)]

Site	Inst Type	Deployment No.	ADVF & Data Logger S/N	Paros S/N	Paros Calibration Filename	OBS No.1 S/N	OBS No.2 S/N	Samp Rate (Hz)	Burst Interval (s)	Samples Per Burst	Burst Length (s)	Synced w/ S/N	Coordinate System
MIA	ADVF Hydra	1	231/G64	60005*	T60005.drk*	829	830	20	7200	24000	1200	Master to S/N 244 & ABS System No.1	XYZ
		2	N/A									N/A	
	ADVF Hydra	1	244/G62	60006*	T60006.drk*	924	925	20	7200	24000	1200	Slave to S/N 231	XYZ
		2	244/G62	60005*	T60005.drk*	924	925	10	3600	12000	1200	none	XYZ

* Note: Firmware problems prevented correct pressure measurements.

2.4.1.3 SonTek Pulse-Coherent Acoustic Doppler Profiler (PCADP) Hydra System

The SonTek pulse-coherent acoustic Doppler profiler Hydra system (PCADP Hydra) incorporated a pulse-coherent acoustic Doppler profiler (PCADP), a frequency Paroscientific digiquartz pressure sensor (Paros), and two optical backscatter sensors (OBS) manufactured by D & A Instruments. Serial numbers and sampling parameters are listed in table 10.

The PCADP measures velocities along three beams oriented 15 degrees from the vertical and separated radially by 120 degrees. It was mounted about 1.3 m above the bed (before tripod settling), looking down. The PCADP sampled at 1 Hz in 10-cm cells for 20 minute bursts every hour. Bursts were centered on the hour (that is, they began at HH:50:00). Other sampling parameters are shown in table 10.

Pulse-coherent systems use a pair of short pulses to measure velocities using the Doppler principle, which makes it possible to measure velocity profiles with a higher spatial resolution (or smaller cell size) than single-pulse acoustic Doppler profilers can achieve. The instrument emits the pulses a short time s apart, and measures the phase shift between the reflected signal at time t and at time $t + \tau$. The phase shift is determined only up to a multiple of 2π , so the along-beam velocity derived from it is determined only over a limited range. In other words, the pulse-coherent method cannot by itself distinguish between velocities v and $v + kV_a$, where k is any integer and V_a is the ambiguity velocity. The ambiguity velocity is inversely related to the maximum distance from the transducer at which measurements are made (the profiling range). Computed velocity, v , lies in the range $-V_a/2 < v < V_a/2$. If the actual velocity is outside this range, the difference between the computed and actual velocity is called ambiguity error. For a more detailed description on the operation and accuracy of the PCADP see Lacy and Sherwood (in press).

Even in boundary layer applications where the profiling range is relatively short, the range of velocities that are measured unambiguously by pulse-coherent systems is too limited for many wave-dominated environments. For example, assuming a beam 15° from vertical and a 1-m profiling range, $V_a/2 = 19$ cm/s for along-beam velocities. In terms of an east/north/up coordinate system, horizontal velocities outside the range ± 73 cm/s produce ambiguity errors.

SonTek's approach to resolving ambiguity errors relies on a pulse pair, called the resolution pulse, emitted by the PCADP at the beginning of each set of profiling pings. It measures along-beam velocities in a 10-cm cell at a user-specified distance that is less than the profiling range, so its ambiguity velocity is greater than that of the profiling pings. The velocity measured by the resolution pulse (called the resolution velocity) is used to detect ambiguity errors in the profile velocities (fig. 6). The resolution pulse extends the range of velocities that can be measured unambiguously, but if actual velocities exceed the ambiguity velocity of the resolution pulse, the error cannot be detected.

The resolution cell should, in principle, be as close as possible to the transducer because the ambiguity velocity is inversely proportional to the measurement range. In practice we found that the resolution velocities were too noisy to reliably identify ambiguity errors if the resolution cell was too close to the transducer. We used a resolution pulse with a blanking distance of 24 cm and a range of 49 cm, which positions the 10-cm resolution cell 24 to 34 cm from the transducer. The range must be greater than the maximum extent of the resolution cell to ensure separation of the reflections of the two pulses. The profiling range was approximately 1 m, so the resolution pulse increased the range of measurable velocities by about a factor of two (table 10).

The PCADP also measured and recorded water temperature and compass heading, pitch, and roll. Power was supplied from a separate battery canister. Frequency Paroscientific digiquartz pressure sensors require a calibration file; the filename for each calibration is listed in table 10, and the calibration files are provided on DVD02 accompanying this report.

The pressure sensor deployed with the PCADP Hydra system was damaged during Deployment 1, therefore, a different frequency Paros pressure sensor was deployed with this system during Deployment 2. During Deployment 2, the PCADP was supposed to provide a trigger for ABS System No.1 data collection, but due to an oversight in programming the PCADP, the sync did not work.

The OBS measurements collected by the PCADP Hydra system were affected by both bio-fouling and the interference problem discussed previously and in appendix F.

PCADP raw binary files and burst means of select parameters are supplied on the accompanying DVDs; see appendix D.3 for details. Pressure burst means have been corrected for atmospheric pressure using the methods described for the PCADP in section 2.4; heading has not been corrected to true North. Bursts that do not meet quality control criteria, as described in section 3.3, are not included in the ASCII data file.

Table 10. SonTek pulse-coherent acoustic Doppler velocimeter (PCADP) serial numbers (S/Ns) and sampling parameters.

[(Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor)]

Parameter	Deployment 1	Deployment 2
PCADP probe and logger serial number	H40/G136	H40/G136
Paros serial number	70136	66917
Frequency Paros calibration file	P70136.drk	T66917.drk
OBS 1 serial number	694	694
OBS 2 serial number	794	794
Coordinate System	Beam	Beam
Cell size (m)	0.108	0.094
Blank distance (m)	0.10	0.10
Number of cells	8	8
Averaging interval (s)	1.0	1.0
Profile interval (s)	1.0	1.0
Ping interval (s)	0.0	0.0
Burst interval	3600	3600
Profiles per burst	1200	1200
Pulse length (m)	0.02	0.02
Maximum range (m)	0.88	0.76
User pulse lag (m)	0.90	1.00
System pulse lag (m)	1.09	0.97
User resolution lag (m)	0.45	0.45
System resolution lag (m)	0.46	0.49
Minimum correlation level (%)	25	25
Synchronized w/ S/N and Instrument	none	Master to ABS System No.1

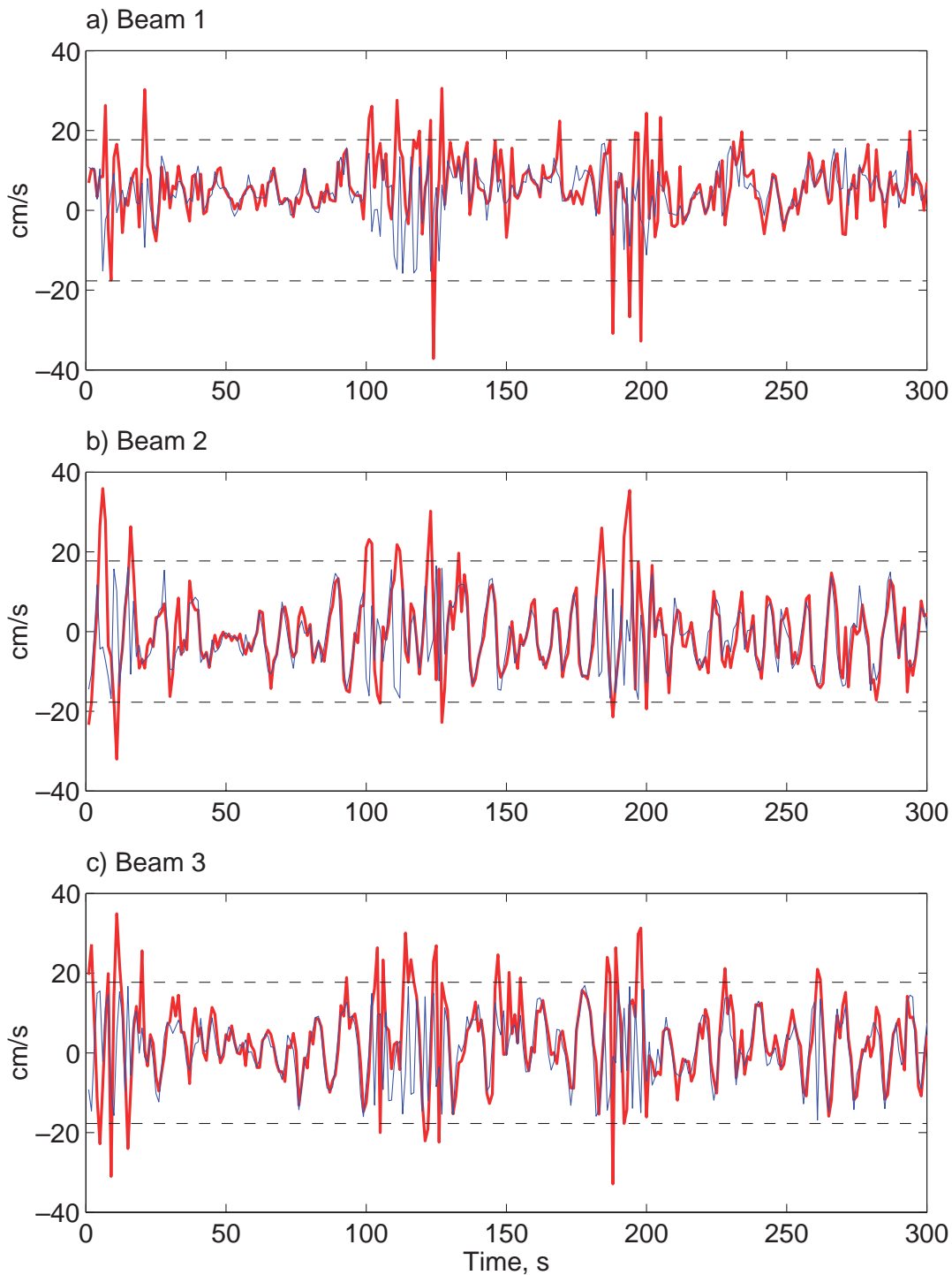


Figure 6. Times series of measured resolution velocity from burst 6, Deployment 1 for each beam of the pulse-coherent acoustic Doppler velocimeter (PCADP) from data collected at Site MIA. Time is seconds since beginning of burst. The thick red line is the resolution velocity, the blue line is the velocity in cell 2, which is the closest cell to the resolution cell. The dashed lines show the range of velocities that can be measured in the profiling cells (such as cell 2) without ambiguity errors. The range that can be measured by the resolution velocity cell is greater, so when water velocities have magnitudes outside the dashed lines, the resolution velocity differs from the cell 2 velocity, and can be used to correct the profile velocities. However, the resolution velocity is noisy. All velocities in this plot are along-beam velocities.

2.4.1.4 SonTek Acoustic Doppler Profiler (ADP)

SonTek acoustic Doppler profilers (ADPs) measure profiles of three velocity components (for example, east, north, and up) throughout the water column. Profiles were collected for 10 minutes every 30 minutes. Vertical cell size was 0.5 m, starting 0.4 m from the transducer. Data were collected for 65 cells, up through the water column and past the level of the water surface. The instruments were set to measure as often as possible, and averaged profiles were recorded every half hour. The start time on the instrument was set so that the profiles were centered exactly on the hour and half-hour (that is HH:55:00).

Two of the ADPs were equipped with internally mounted Druck pressure sensors and SonPro wave measurement software. Burst measurements of pressure (for wave and tide information) were to be collected with every other current profile; however, an incompatibility between the pressure sensor and software prevented the data from being collected. Sampling parameters are shown in table 11 for reference. Calibration information for the Druck pressure sensors are in the files specified in table 11 and are located on DVD02 accompanying the report.

The ADPs also measured and recorded water temperature, and compass heading, pitch, and roll. Power was supplied from a separate battery canister. The same instruments and sampling scheme were used for both deployments. ADP sampling parameters are summarized in table 11.

Table 11. SonTek acoustic Doppler profiler (ADP) serial numbers and sampling parameters.

Parameter	ND-Dep 1	ND-Dep 2	MD-Dep 1	MD-Dep 2	SD-Dep 1	SD-Dep 2
ADP Serial Number	C134	C134	4081	4081	C132	C132
Druck calibration file	958200.drk	958200.drk	N/A	N/A	995410.drk	995410.drk
Cell size (m)	0.50	0.50	0.50	0.50	0.50	0.50
Blank distance (m)	0.40	0.40	0.40	0.40	0.40	0.40
Number of cells	65	65	65	65	65	65
Averaging interval (s)	600	600	600	600	600	600
Profile interval (s)	1,800	1,800	1,800	1,800	1,800	1,800
Ping interval (s)	0.0	0.0	0.0	0.0	0.0	0.0
Coordinate System	ENU	ENU	ENU	ENU	ENU	ENU
Wave Sampling Parameters:						
Wave series type	PUV_Series	PUV_Series	N/A	N/A	PUV_Series	PUV_Series
Record Waves every <i>X</i> profiles	2	2			2	2
Wave burst sampling rate (Hz)	2	2			2	2
Number of samples per burst	2,048	2,048			2,048	2,048
Length of burst (s)	1,024	1,024			1,024	1,024
User resolution lag (m)	0.40	0.40			0.40	0.40
System resolution lag (m)	0.40	0.41			0.41	0.42
Maximum vertical velocity (m/s)	0.96	0.94			0.94	0.92
Maximum horizontal velocity (m/s)	2.28	2.22			2.22	2.17
Minimum correlation level (%)	25	25			25	25

2.4.1.5 Aquatec Acoustic Backscatter System (ABS)

The Aquatec acoustic backscatter system (ABS) measures profiles of backscatter intensity (related to suspended sediment) at three acoustic frequencies (1.0, 2.5, and 5.0 Hz) to a distance of approximately 1.28 m in approximately 1-cm bins or cells. The transducers were mounted downward looking in a triangular arrangement with the center of the transducers approximately 8 cm apart. The battery supply and data logger were contained in separate pressure casings. Sampling occurred at 64 Hz with an average profile recorded once every second. Profiles were collected for

30 minutes every hour (1,800 profiles). The start time on the instrument was set so that bursts were centered on the hour (that is, they began at HH:45:00). Gain was set on high and time-varying gain was on.

The ABS at Site MIA, System No.1, was triggered by ADVF S/N 231, which also triggered ADVF S/N 244 during Deployment 1. Although the trigger from the ADVF came every two hours, the ABS was programmed to burst every hour. Therefore, a burst was collected even in the off hours of the ADVF. During Deployment 2, this ABS was supposed to be triggered by the PCADP, but due to an oversight the synchronization did not occur. Nevertheless, the ABS collected bursts every hour.

The ABS saves a binary file after each burst. The structure of the filename is the date and time of the start of the burst in the following format: YYYYMMDDHHMMSS. The file extension is .aqa if the ABS started data collection on its own or .aqf if data collection was triggered via the synchronization cable. The ABS files are provided on DVD01. In order to organize the large volume of ABS data files, the files have been organized by deployment and week, with each deployment split into 5 week-long segments. The week-long groupings of the binary data files are packaged as .zip files.

A Matlab m-file, LoadABS.m that reads the ABS binary files into Matlab is included on DVD02. (LoadABS.m is functionally the same as the 10/16/2003 version of readaqa_oleg.m.) This m-file is provided as an example for users. The validity and usability of the m-file is in no way guaranteed; use is at your own risk.

Lab calibration of the ABS revealed that cell 128, the cell furthest from the transducer, is actually 118 cm away from the transducers, not 128 cm. Therefore, the first 10 cells of the ABS record should be ignored, and cell 10 should be treated as 1 cm away from the transducer. The ABS results are reported in arbitrary units. Calibrations with suspended sediment are needed to convert these units to a concentration. The USGS is currently developing methods to perform such calibrations.

Table 12 Aquatec acoustic backscatter system (ABS) serial numbers and sampling parameters.

[(ADVF—acoustic Doppler Field velocimeter; PCADP—pulse-coherent acoustic Doppler profiler; S/N—serial number)]

Parameter	MIA	MS
ABS Serial Number	278-017	278-018
System Number	System No.1	System No.2
Frequencies	All three	All three
Storage Resolution	16 bit	16 bit
Mode	Fore	Fore
Gain	Low	Low
Sample rate (Hz)	64	64
Samples per average	64	64
Burst duration (min)	30	30
Logger mode	Auto	Auto
Inter burst interval (min)	60	60
Synchronized with Instrument - Deployment 1	ADVF S/N 231	none
Synchronized with Instrument - Deployment 2	PCADP S/N H40	none

2.4.1.6 Imagenex Imaging and Profiling Sonar

Rotating-head sonars mounted on a tripod collected images of the bottom. Imaging and profiling sonar images provided a picture of the seabed that allowed for the measurement of ripple lengths and orientations. In contrast to vessel-deployed side-scan sonars, mounted sonars allow the collection of an extended time series of images. Their proximity to the bed allows use of higher frequency sound, which is capable of producing higher resolution images. Mounted units rarely experience noise from platform motion.

The rotating head sonar system used in this study included an Imagenex model 858 sonar controlling two model 855 sonar heads. An Onset Computers Corporation Tattletale Model 8 data-logging system turns the sonar on and off and instructs the controller to switch between the two heads. The sonar controller stores data to a small computer system interface (SCSI) hard drive in a proprietary format. Figure 7 shows the location and orientation of the two sonar heads on the tripod. The imaging head produces a fan beam and rotates about a vertical axis, producing a plan view image of the sea floor (bottom left image in fig. 7). The profiling head produces a narrow conical beam and rotates about a horizontal axis producing a profile of the bed (upper left image in fig. 7). Both transducers emit sound at 2.25 MHz. They rotate through 360 degrees producing 400 and occasionally 600 shots. Each shot is comprised of 2000 points collected at 200 ksamples/sec for a range of 7.5 meters. The sonars collected images every 2 hours, but a data logger problem resulted in the intermittent loss of numerous frames.

Batteries and data logger were each housed in separate pressure casings. Instrument settings are summarized in table 13.

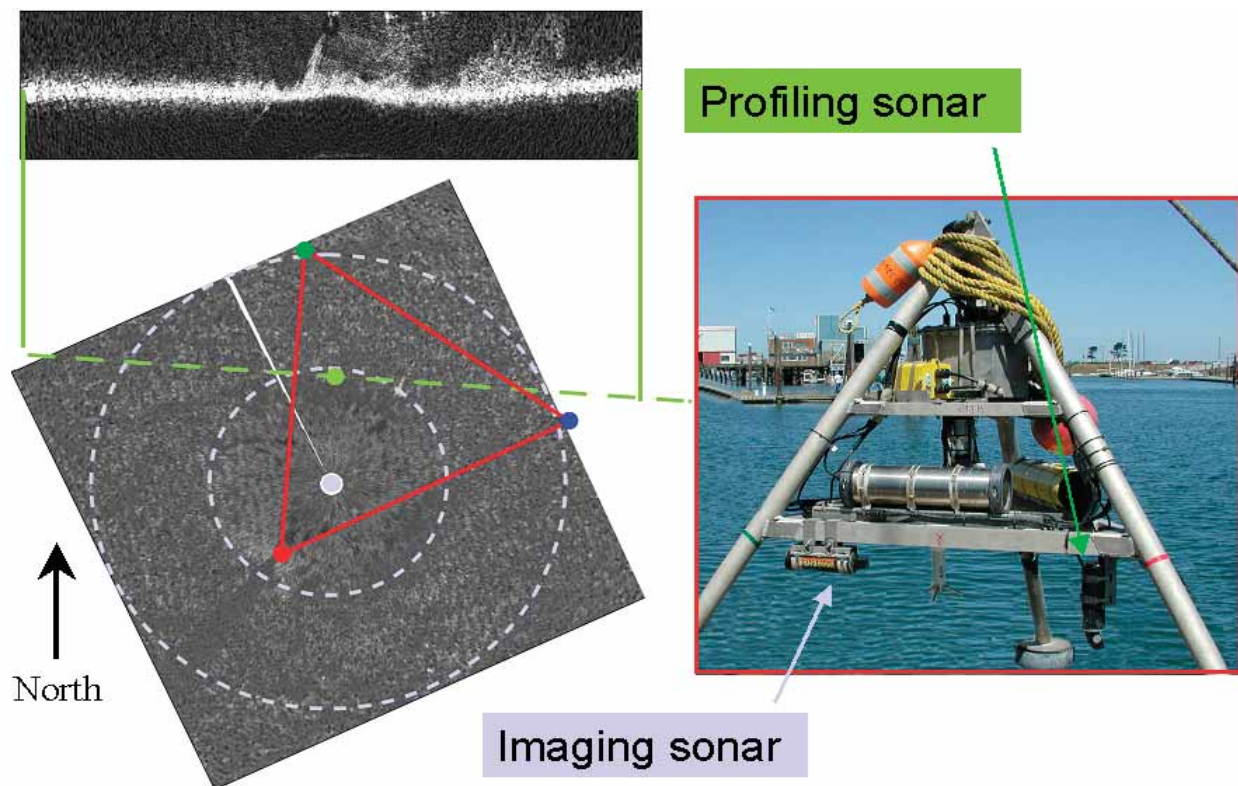


Figure 7. Orientation and arrangement of sonar instrumentation during Deployment 1 overlaid on example images from May 13, 2001. Location of tripod feet are shown with colors matching the tape on the legs. The green dashed line is the approximate trace of the profiler (located at pale green dot). The dashed grey circles indicate ranges of 1 and 2 meters from a point on the seabed located below the fan-beam transducer.

Table 13. Imaging and profiling sonar sampling parameters.

Parameter	Deployment 1	Deployment 2
Burst Period	2 hours	2 hours
Shots per Rotation	400-600	400-600
Range	7.5 meters	7.5 meters
Number of points per shot	2,000	2,000
Rate	200 ksamples/sec	200 ksamples/sec

2.4.1.7 D&A Optical Backscatter Sensors (OBS)

Optical backscatter sensors (OBS) were deployed on each tripod at all sites to provide estimates of suspended sediment concentration. The gain of the OBS was set at mid-range, out of three possible coarse gain settings.

The OBS signal is an analog voltage ranging from 0 to 5 V. This analog signal is converted to a digital output ranging from 0 to 65535 counts by 16-bit analog-digital converters within the individual Hydra systems. This reading of the OBS is then recorded in counts by the Hydra system. Calibration of the A/D converter in each Hydra system was performed; the results are presented in appendix E.1. This calibration is specific to the A/D converter and therefore specific to a particular Hydra system, not a particular OBS.

OBS respond differently depending on the type and size distribution of sediment suspended within its sampling volume (D&A Instrument Co., 1991). Therefore, a calibration for each OBS was performed with sediment collected at the site where each OBS was deployed. This calibration allows for the conversion of the digital value recorded by the Hydra system, counts, to estimates of suspended sediment concentration in kg/m^3 . The results of this calibration are presented in appendix E.2.

2.4.2 Tripods

The frames of the five tripods deployed at Sites ND, MD, MS, MIB, and SD were identical (figs. 8, 11, and 16). They were constructed of welded aluminum tubing with an outside diameter of 7.62 cm, and were approximately 2.5 m high and 3 m wide. The lower crossbars were placed high on the tripods (106 cm above ground, approximately 30 cm above the ADVO sampling volumes) to minimize flow disturbance and bottom scour. The circular feet had a diameter of 30.5 cm and were ballasted with removable cylindrical lead weights (diameter = 34.3 cm; height = 11.4 cm) weighing approximately 113 kg in air.

The frame of the tripod deployed at Site MIA was constructed of welded stainless steel tubing of various sizes. The legs were made from a tubing with an outside diameter of 4.23 cm. Crossbars provided additional support to the 3 main legs. The lower crossbars and upper frame of the tripod were constructed of a cylindrical tubing with a 2.54 cm outer-diameter, where as the upper crossbars were constructed of 2.57 cm square tubing. The tripod, including lead feet, was approximately 2.46 m high and 2.92 m wide (fig. 13). Two 2-cm-thick plastic panels were mounted horizontally at heights of 1.65 and 1.91 m. Aluminum channels, to which battery cases and data loggers could be attached, were mounted on the plastic platforms. Instruments were mounted such that their sampling volumes would be at least 30 centimeters away from the lower platform. The removable square lead feet were 34.0 cm on each side and 7 cm tall, weighing approximately 68 kg in air.

The legs of each of the six tripods were labeled as red, green, and blue, with the legs designated in that order in a clockwise fashion. All compass containing instruments were oriented such that the x-direction was aligned to be perpendicular to the plane passing through the red and green legs.

For simplicity, the descriptions of the locations and orientations of instruments will be referenced to the color of the tripod legs as shown in figs. 8, 11, 13, and 16.

All six tripods were lowered to the bottom using a crab block on 2.54-cm (1 inch) polypropylene line, which was left tethered to a surface float (crab-pot buoy). Tripods were recovered with the same lifting line. Each deep-water tripod had a backup recovery system, which was never needed, consisting of a float, line canister, and acoustic release.

Instrument placement was similar on the three deep water tripods (fig. 8). Additionally placement of the ADVO Hydra system was similar on all the tripods which contained an instrument of that type. Heights of the sensors above the deck and horizontal separations were measured prior to each deployment (table 14). The ADVOs recorded distance to the sea bed with each burst. These data indicate that the elevations of sensors relative to the sea bed varied during each deployment and were always less than the distances listed in table 14.

Check-out sheets were designed to assure the correct and safe set-up and documentation of the tripods and instrumentation during the deployments and retrievals. Example check-out sheets are included in appendix A.

Field logs, including tripod retrieval conditions and damage to instruments and tripods, are reproduced in appendix B.

2.4.2.1 Site ND

The tripod at Site ND was deployed with an ADP and an ADVO Hydra system. The ADP was oriented such that the legs of the tripods did not interfere with the path of the ADP beams (fig. 9). The battery canister for the ADP was mounted on a lower crossbar (fig. 10). The data logger for the ADVO Hydra system was mounted on the upper platform of the tripod, where as the battery canister was mounted on a lower crossbar. The OBS were mounted on the blue leg of the tripod with OBS 1 pointing towards the green leg and OBS 2, the lower OBS, pointing towards the red leg. Figure 8 shows the approximate locations of the instruments deployed during both deployments at Site ND. The exact heights of the transducers during each deployment are listed in table 14.

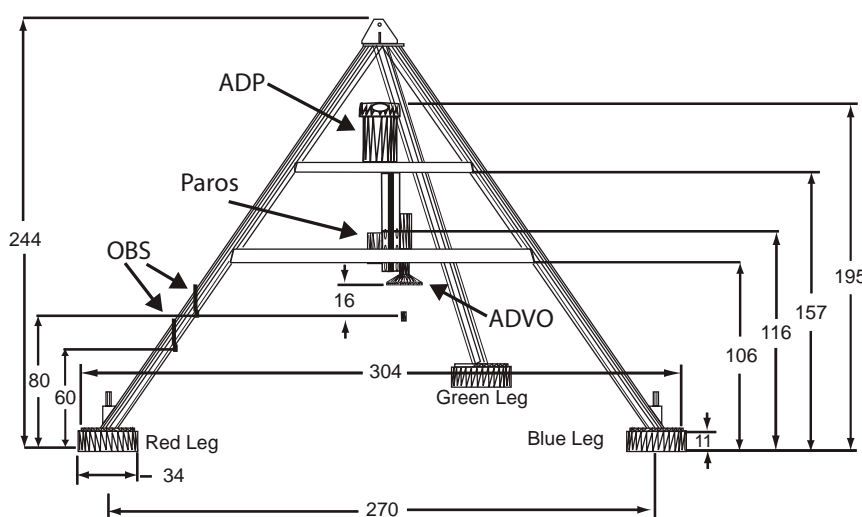


Figure 8. Schematic drawing of the tripods deployed at Sites ND, MD, and SD. Dimensions indicated are in cm and are nominal; see table 14. ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler.

Table 14. Relative position of instruments on all six tripods.

[(ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler; S/N—serial number)]

Distance (cm)	Deployment No.	ND	MD	MS	MIA	MIB	SD
Deck to ADVO transmitter	1	95.3	95.3	96.5		80.7	95.7
	2	96	95.5	95.5		80.5	95.5
Deck to ADVO Paros sensor	1	116	117	124.5		119	117
	2	118	117.5	126		118.5	116.5
Horizontal dist between ADVO and Paros	1						
	2	19	15.5	16		18	18.5
Deck to ADVO OBS 1 sensor	1	79.9	80	80		79.5	79.5
	2	77	80	78		79.5	80
Deck to ADVO OBS 2 sensor	1	60.2	59.5	60.5		64.5	60.5
	2	60.5	59	59		64.5	60.5
Deck to ADVF S/N 231 transmitter	1				82		
	2						
Deck to ADVF S/N 231 Paros sensor	1				127		
	2						
Deck to ADVF S/N 231 OBS 1 sensor	1				59.7		
	2						
Deck to ADVF S/N 231 OBS 2 sensor	1				44.7		
	2						
Deck to ADVF S/N 244 transmitter	1				81.4		
	2				87.5		
Deck to ADVF S/N 244 Paros sensor	1				127.5		
	2				130.5		
Horizontal dist between ADVF and Paros	1						
	2				22		
Deck to ADVF S/N 244 OBS 1 sensor	1				59.5		
	2				60		
Deck to ADVF S/N 244 OBS 2 sensor	1				116.4		
	2				45		
Deck to top of ADP	1	195	195.5				195.5
	2	195.5	195.5				195
Deck to PCADP transmitter	1				130.3		
	2				131.5		
Deck to PCADP Paros sensor	1				127.2		
	2				130.5		
Horizontal dist between PCADP and Paros	1						
	2				37		
Deck to PCADP OBS 1 sensor	1				55.2		
	2				54.5		
Deck to PCADP OBS 2 sensor	1				90.0		
	2				90		
Deck to ABS transmitters	1			105	136.3		
	2			106.5	138.3		
Deck to profile sonar transmitter	1					96	
	2					97	
Deck to imaging sonar transmitter	1					67	
	2					71.5	

Instrumentation and sampling schemes were similar for both deployments. A summary of the instrument sampling parameters and serial numbers are found in table 15. For more specific information about a particular instrument see section 2.4.1.

The compass in the ADVVO was damaged just before or shortly after the first deployment. The heading, pitch, and roll are all slightly off for both deployments. Therefore, the velocities, particularly vertical velocity, for both deployments should be treated with caution. Instrument log sheets suggest that the actual heading may be within 30 degrees of that recorded by the instrument. The ADP also collected heading information and can be used in determining the orientation of the tripod and ADVVO since the orientation of the two instruments on the tripod coincided.

The tripod at Site ND experienced mild biofouling during both deployments. The effects of the biofouling are apparent in the Deployment 1 OBS records collected by the ADVVO Hydra system. The OBS measurements were additionally affected by the interference problem discussed previously and in appendix F.

2.4.2.2 Site MD

The tripod at Site MD was deployed with an ADP and an ADVVO Hydra system. The ADP was oriented such that the legs of the tripods did not interfere with the path of the ADP beams (fig. 9). The battery canister for the ADP was mounted on a lower crossbar (fig. 10). The data logger for the ADVVO Hydra system was mounted on the upper platform of the tripod, where as the battery canister was mounted on a lower crossbar. The OBS were mounted on the blue leg of the tripod with OBS 1 pointing towards the red leg and OBS 2, the lower OBS, pointing towards the green leg. Figure 8 shows the approximate locations of the instruments deployed during both deployments at Site MD. The exact heights of the transducers during each deployment are summarized in table 14.

Instrumentation and sampling schemes remained similar for both deployments. A summary of the instrument sampling parameters and serial numbers are found in table 16. For more specific information about a particular instrument see section 2.4.1.

The tripod at Site MD experienced mild biofouling during both deployments. The OBS measurements collected by the ADVVO Hydra system were affected by both biofouling and the interference problem discussed previously and in appendix F.

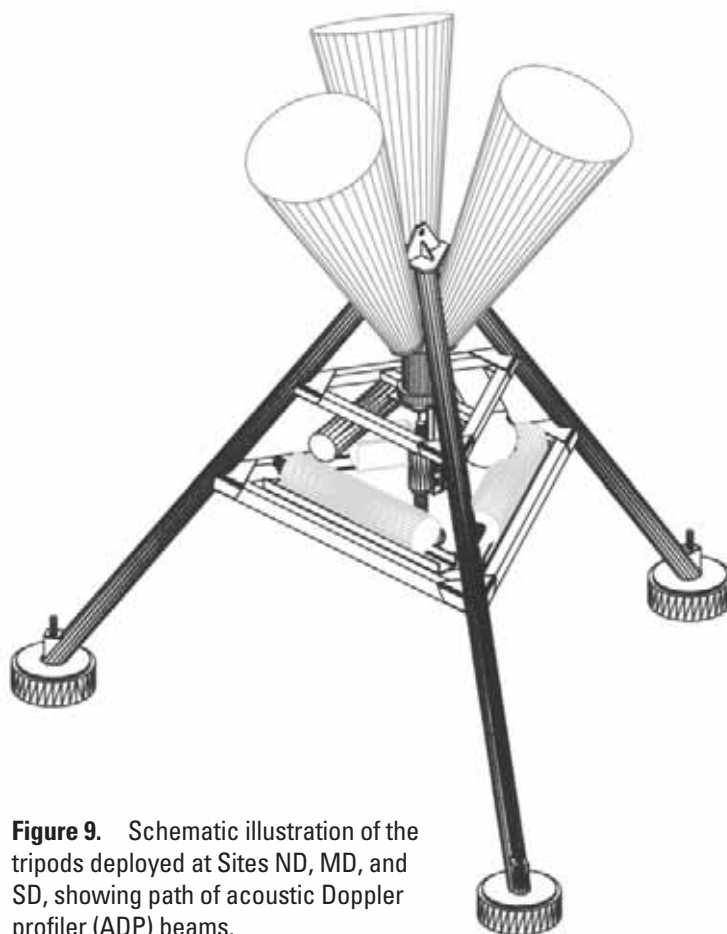


Figure 9. Schematic illustration of the tripods deployed at Sites ND, MD, and SD, showing path of acoustic Doppler profiler (ADP) beams.

Table 15. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site ND.

[Distances are in cm and are nominal; see table 14. (ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 1538	06/08/01 0314
Retrieval date and time	06/05/01 2025	07/11/01 1625
ADVO and ADVO Hydra data logger S/N	B45	B45
ADVO Hydra Paros S/N	66890	66890
ADVO Hydra OBS1 S/N/leg mounted on/ pointing towards	795/blue/green	795/blue/green
ADVO Hydra OBS2 S/N/leg mounted on/ pointing towards	796/blue/red	796/blue/red
ADVO Hydra burst interval (s)	3,600	3,600
ADVO Hydra burst length (s)	1,200	1,200
Sampling rate (Hz)	2	2
Samples per burst	2,400	2,400
ADP S/N	C134	C134
Druck calibration filename	958200.drk	958200.drk
Profile Interval (s)	1,800	1,800
Averaging Interval (s)	600	600
Deck to ADVO transmitter	95.3	96
Deck to ADVO Paros sensor	116	118
Horizontal dist between ADVO and Paros		19
Deck to ADVO OBS 1 sensor	79.9	77
Deck to ADVO OBS 2 sensor	60.2	60.5
Deck to top of ADP	195	195.5

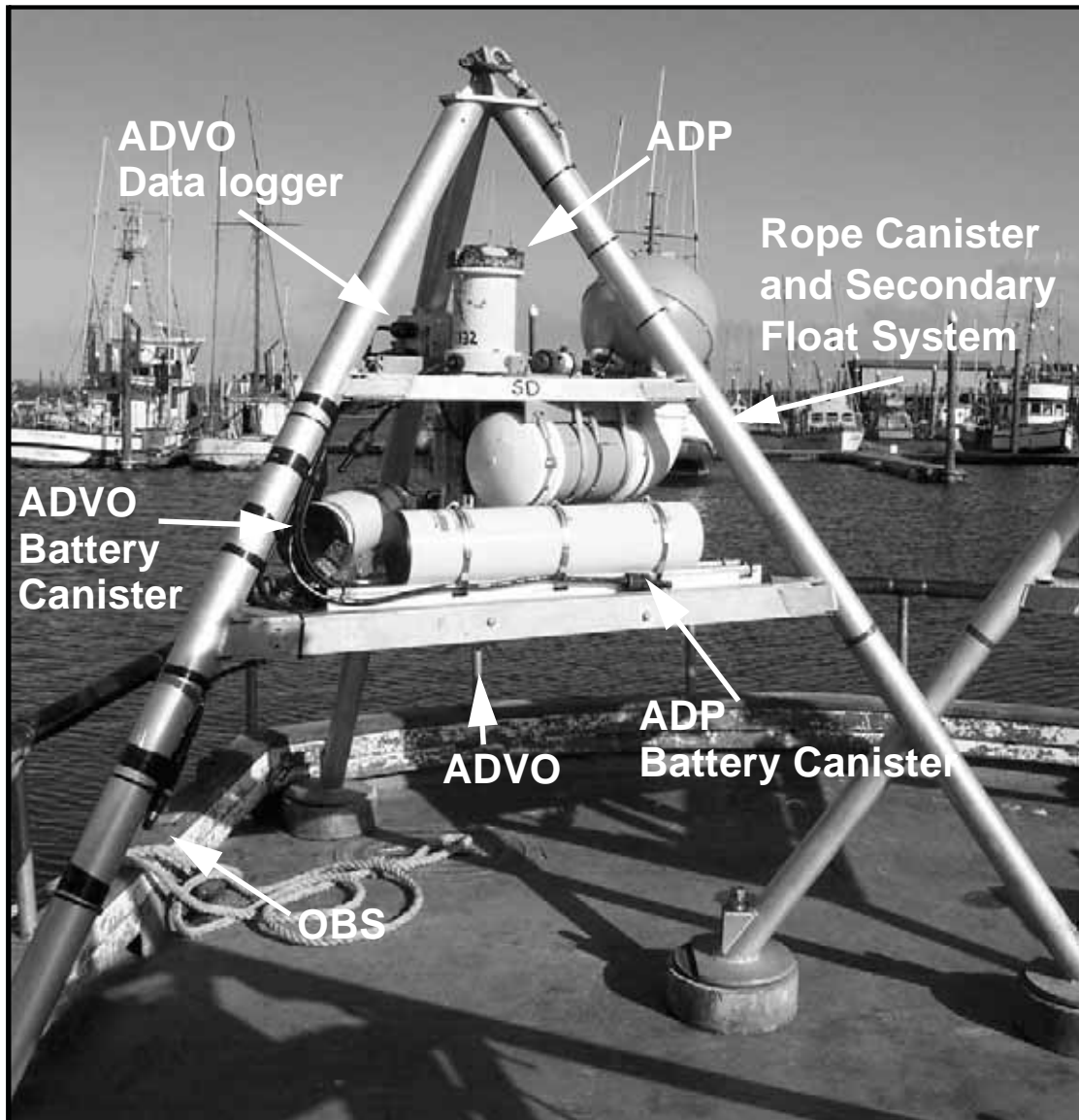


Figure 10. Photograph of the tripod deployed at Site SD. The set-up of the tripods at Sites ND and MD were essentially the same. ADVO—acoustic Doppler velocimeter; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler.

Table 16. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site MD.

[Distances are in cm and are nominal; see Table 14. (ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 2038	06/08/01 0228
Retrieval date and time	06/05/01 1848	07/11/01 1718
ADVO and ADVO Hydra data logger S/N	B51	B51
ADVO Hydra Paros S/N	69130	69130
ADVO Hydra OBS1 S/N/leg mounted on/ pointing towards	1242/blue/red	1242/blue/red
ADVO Hydra OBS2 S/N/leg mounted on/ pointing towards	1135/blue/green	1135/blue/green
ADVO Hydra burst interval (s)	3,600	3,600
ADVO Hydra burst length (s)	1,200	1,200
Sampling rate (Hz)	2	2
Samples per burst	2400	2–400
ADP S/N	4081	4081
Profile Interval (s)	1,800	1,800
Averaging Interval (s)	600	600
Deck to ADVO transmitter	95.3	95.5
Deck to ADVO Paros sensor	117	117.5
Horizontal dist between ADVO and Paros		15.5
Deck to ADVO OBS 1 sensor	80	80
Deck to ADVO OBS 2 sensor	59.5	59
Deck to top of ADP	195.5	195.5

2.4.2.3 Site MS

The tripod at Site MS was deployed with an ADVO Hydra system and an ABS. The data logger for the ADVO Hydra system was mounted on the upper platform of the tripod while the battery canister was mounted on a lower crossbar. The OBS were mounted on the blue leg of the tripod with OBS 1 pointing towards the green leg and OBS 2, the lower OBS, pointing towards the red leg. The data logger and battery canister for the ABS were mounted on the lower crossbars. Figure 11 shows the approximate locations of the instruments deployed during both deployments at Site MS. The exact heights of the transducers during each deployment are summarized in table 14.

ADVO S/N B158 was damaged during set-up of the tripod and therefore ADVO S/N B167 served as a substitute during Deployment 1. ADVO S/N B158 was repaired and deployed with its original data logger during Deployment 2. Otherwise, all instrumentation remained the same on this tripod for both deployments and sampling schemes remained similar for both deployments. A summary of the instrument sampling parameters and serial numbers are found in table 17. For more specific information about a particular instrument see section 2.4.1.

The tripod at Site MS experienced moderate biofouling during both deployments. The OBS measurements collected by the ADVO Hydra system were affected by both biofouling and the interference problem discussed previously and in appendix F.

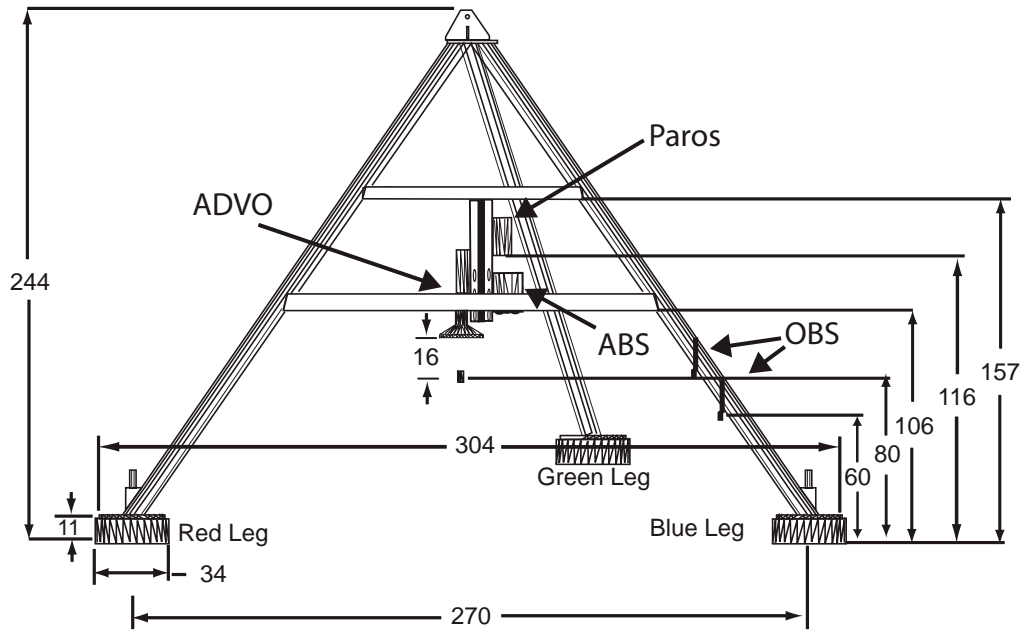


Figure 11. Schematic drawing of the tripod deployed at Site MS. Dimensions indicated are in cm and are nominal; see table 14. ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; ABS—acoustic backscatter system; ADP—acoustic Doppler profiler.

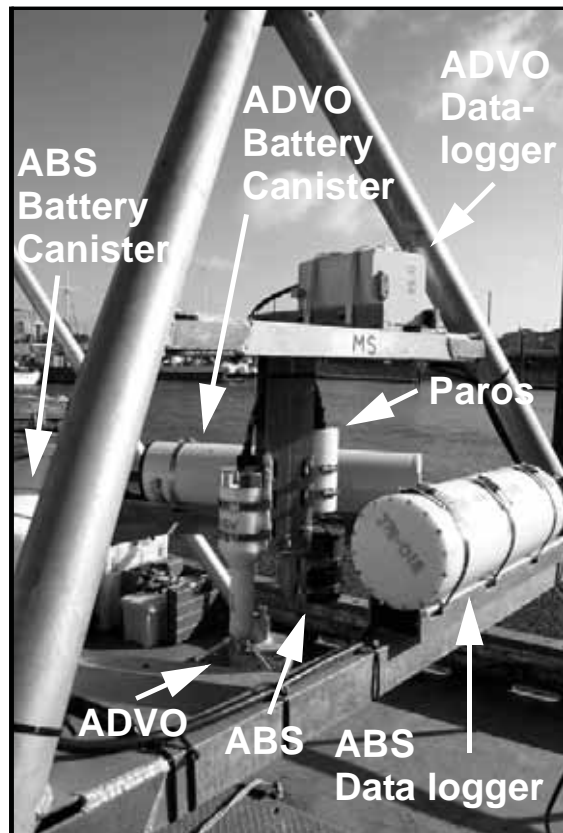


Figure 12. Close-up photograph of the tripod deployed at Site MS showing the locations of the acoustic backscatter system (ABS) and acoustic Doppler velocimeter Ocean (ADVO) Hydra systems. ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; ABS—acoustic backscatter system.

Table 17. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site MS.

[Distances are in cm and are nominal; see Table 14. (ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ABS—acoustic backscatter system; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 2005	06/07/01 2142
Retrieval date and time	06/05/01 1932	07/11/01 2105
ADVO and ADVO Hydra data logger S/N	B167/B158	B167/B158
ADVO Hydra Paros S/N	69128	69128
ADVO Hydra OBS1 S/N/leg mounted on/ pointing towards	928/blue/green	928/blue/green
ADVO Hydra OBS2 S/N/leg mounted on/ pointing towards	1104/blue/red	1104/blue/red
ADVO Hydra burst interval (s)	3,600	3,600
ADVO Hydra burst length (s)	1,200	1,200
ADVO Hydra sampling rate (Hz)	2	2
ADVO Hydra samples per burst	2400	2400
ABS S/N/System No.	278-018/ System No.2	278-018/System No.2
Sample rate (Hz)	64	64
Samples per average	64	64
Burst duration (min)	30	30
Inter burst interval (min)	60	60
Synchronized with Instrument	none	none
Deck to ADVO transmitter	96.5	95.5
Deck to ADVO Paros sensor	124.5	126
Horizontal dist between ADVO and Paros		16
Deck to ADVO OBS 1 sensor	80	78
Deck to ADVO OBS 2 sensor	60.5	59
Deck to ABS transmitter	105	106.5

2.4.2.4 Site MIA

The tripod at Site MIA was deployed during Deployment 1 with two ADVF Hydra systems, a PCADP Hydra system, and an ABS. Instrument data loggers and battery canisters were mounted on the two upper sections of the tripod. Instrumentation, with the exception of the OBS, was mounted from the bottom of the lower platforms of the tripod in order to position the instrument sampling volumes away from the flow disturbance caused by the upper section of the tripod. The ADVFs were mounted at the same height above the bottom (fig. 12). The PCADP and ABS were mounted next to each other so as to collect profiles of essentially the same water column.

The OBS were mounted on all three legs of the tripod at several heights above the bottom, some corresponding to the locations of the sampling volumes of the ADVFs, PCADP, and ABS. The OBS deployed with ADVF Hydra system S/N 231 were mounted on the red leg, with OBS1, S/N 829, pointing towards the blue leg and OBS 2, S/N 830, pointing towards the green leg. The OBS deployed with ADVF Hydra system S/N 244 were mounted on the green leg, with OBS 1, S/N 924, pointing towards the center of the tripod and OBS 2, S/N 925, pointing outward. The OBS deployed with the PCADP Hydra system were mounted on the blue leg, with OBS 1, S/N 694, pointing towards the red leg and OBS2, S/N 794, pointing towards the green leg.

Three Paros pressure sensors were mounted at the same height on the tripod. Figure 13 shows the approximate location of the instruments deployed during Deployment 1 at Site MIA; figure 14 is a close-up photograph of the two ADVFs and other instrumentation before Deployment 1.

The tripod at Site MIA was found damaged after Deployment 1. The line from the tripod to the surface buoy had become wrapped around the instruments and tripod during a storm. On lifting

the tripod with the tangled rope, the tripod was bent and the plastic platform cracked. Additionally, a probe arm of ADVF S/N 231 was snapped off, and Paros S/N 70136 was damaged.

The damage to the tripod was repaired and the sampling plan was modified to accommodate the missing instruments; the loss of some instrumentation resulted in the modification of the setup of the tripod and certain sampling parameters during Deployment 2 (fig. 15). The damaged ADVF Hydra system was removed completely. The damaged Paros, S/N 60006, from ADVF S/N 244 was replaced with the Paros, S/N 60005, from ADVF S/N 231 and a spare Paros, S/N 66917, replaced the damaged Paros, S/N 70136, from the PCADP Hydra system. The OBS deployed with ADVF Hydra system S/N 244 remained the same but the locations at which they were mounted were modified; the OBS were mounted on the red leg with OBS 1, S/N 924, pointing towards the blue leg and OBS2, S/N 925, pointing towards the green leg. The sampling scheme for the lone ADVF Hydra system was modified to sample at 10 HZ every hour.

Otherwise, instrumentation and sampling schemes remained the same on this tripod for both deployments. The exact heights of the transducers during each deployment are summarized in table 14. A summary of the instrument sampling parameters and serial numbers are found in table 18. For more specific information about a particular instrument see section 2.4.1.

Owing to a error in a last-minute firmware upgrade, pressure was not correctly collected by either ADVF Hydra system during either deployment. During the second deployment, the PCADP was meant to trigger the ABS but did not, owing to a programming error.

The tripod at Site MIA experienced heavy biofouling during both deployments. The OBS measurements collected by the ADVF and PCADP Hydra systems were affected by both biofouling and the interference problem discussed previously and in appendix F.

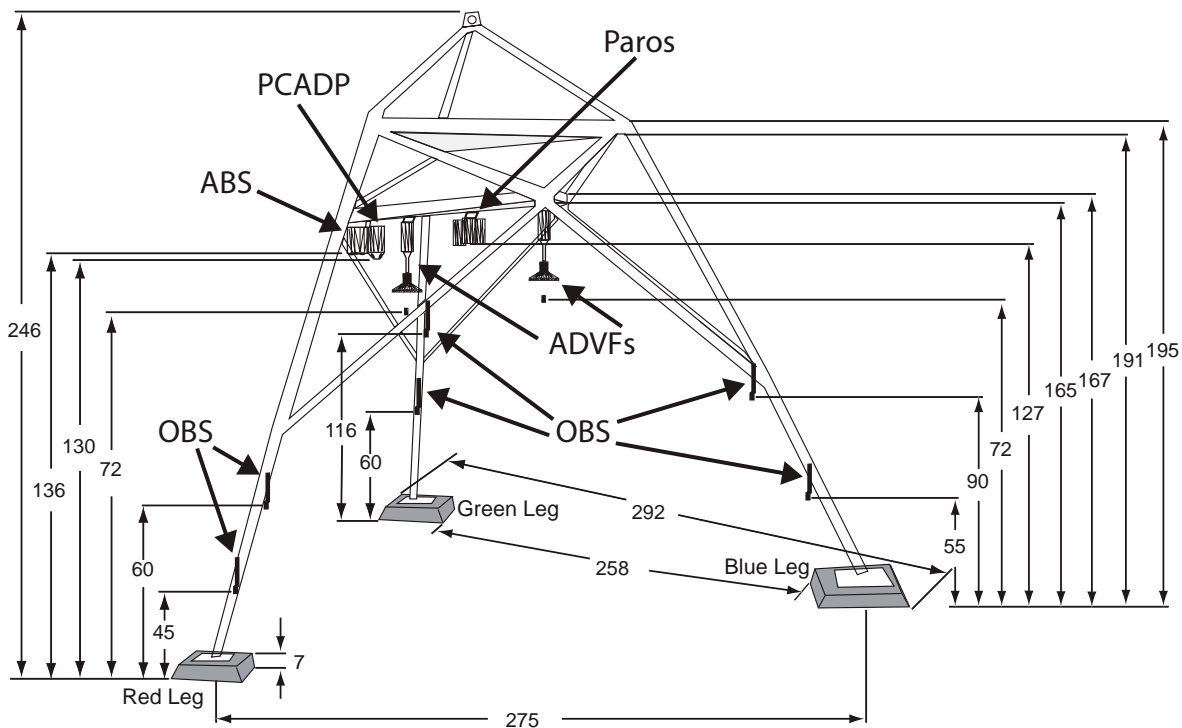


Figure 13. Schematic drawing of the tripod deployed at Site MIA as instrumented during Deployment 1. Dimensions indicated are in cm and are nominal; see table 14. Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler.

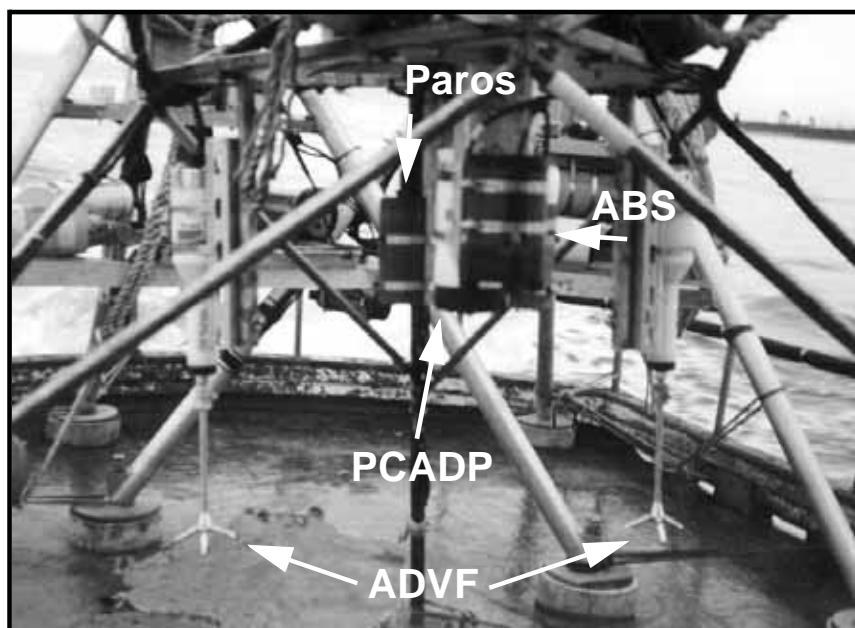


Figure 14. Photograph showing the arrangement of the two acoustic Doppler Field velocimeters (ADVF) during Deployment 1 at Site MIA. Paros—Paroscientific pressure sensor; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler.

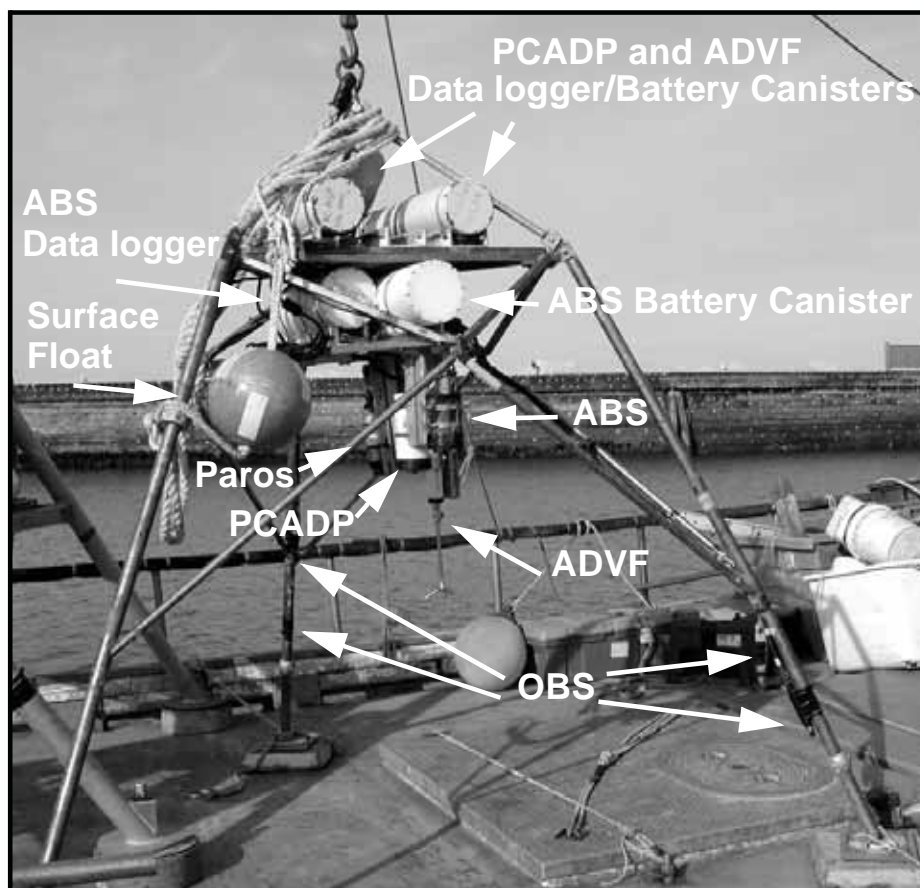


Figure 15. Photograph of the tripod deployed during Deployment 2 at Site MIA. Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler.

Table 18. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site MIA.

[Distances are in cm and are nominal; see table 14. (Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADVF—acoustic Doppler Field velocimeter; ABS—acoustic backscatter system; PCADP—pulse-coherent acoustic Doppler profiler; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 1408	06/05/01 1557
Retrieval date and time	06/08/01 0158	07/11/01 2023
ADVF and ADVF Hydra data logger S/N - System 1	231/G64	N/A
ADVF Hydra Paros S/N - System 1	60005	
ADVF Hydra Paros Calibration filename - System 1	T60005.drk	
ADVF Hydra OBS1 S/N/leg mounted on/ pointing towards - System 1	829/red/blue	
ADVF Hydra OBS2 S/N/leg mounted on/ pointing towards - System 1	930/red/green	
ADVF Hydra burst interval (s) - System 1	7,200	
ADVF Hydra burst length (s) - System 1	1,200	
ADVF Hydra sampling rate (Hz) - System 1	20	
ADVF Hydra samples per burst - System 1t	24000	
Synchronized w/ S/N and Instrument	Master to ADVF S/N 244 and ABS System No.1	
ADVF and ADVF Hydra data logger S/N - System 2	244/G62	244/G62
ADVF Hydra Paros S/N - System 2	60006	60005
ADVF Hydra Paros Calibration filename - System 2	T60005.drk	T60005.drk
ADVF Hydra OBS1 S/N/leg mounted on/ pointing towards - System 2	924/green/center of tripod	924/blue/green
ADVF Hydra OBS2 S/N/leg mounted on/ pointing towards - System 2	925/green/away from center of tripod	925/blue/red
ADVF Hydra burst interval (s) - System 2	7,200	7,200
ADVF Hydra burst length (s) - System 2	1,200	1,200
ADVF Hydra sampling rate (Hz) - System 2	20	20
ADVF Hydra samples per burst - System 2	24,000	24,000
Synchronized w/ S/N and Instrument	Slave to ADVF S/N 231	none
PCADP probe and logger serial number	H40/G136	H40/G136
Paros serial number	70136	66917
Frequency Paros calibration file	P70136.drk	T66917.drk
OBS 1 serial number/leg mounted on/ pointing towards	694blue/red	694/blue/red
OBS 2 serial number/leg mounted on/ pointing towards	794/blue/green	794/blue/green
Cell size (m)	0.108	0.094
Blank distance (m)	0.10	0.10
Number of cells	8	8
Averaging interval (s)	1.0	1.0
Profile interval (s)	1.0	1.0
Ping interval (s)	0.0	0.0
Burst interval (s)	3,600	3,600
Profiles per burst	1,200	1,200
Pulse length (m)	0.02	0.02
Maximum range (m)	0.88	0.76
User pulse lag (m)	0.90	1.00
System pulse lag (m)	1.09	0.97
User resolution lag (m)	0.45	0.45
System resolution lag (m)	0.46	0.49
Maximum vertical velocity (m/s)	0.84	0.76
Maximum horizontal velocity (m/s)	3.24	2.94
Minimum correlation level (%)	25	25
Synchronized w/ S/N and Instrument	none	Master to ABS System No.1
ABS S/N/System No.	278-017/System No.1	278-017/System No.1
Sample rate (Hz)	64	64
Samples per average	64	64
Burst duration (min)	30	30
Inter burst interval (min)	60	60
Synchronized with Instrument	Slave to ADVF S/N 231	Slave to PCADP S/N H40
Deck to ADVF S/N 231 transmitter	82	
Deck to ADVF S/N 231 Paros sensor	127	
Horizontal dist between ADVF S/N 231 and Paros		
Deck to ADVF S/N 231 OBS 1 sensor	59.7	
Deck to ADVF S/N 231 OBS 2 sensor	44.7	
Deck to ADVF S/N 244 transmitter	81.4	87.5
Deck to ADVF S/N 244 Paros sensor	127.5	130.5
Horizontal dist between ADVF S/N 244 and Paros		22
Deck to ADVF S/N 244 OBS 1 sensor	59.5	60
Deck to ADVF S/N 244 OBS 2 sensor	116.4	45
Deck to PCADP transmitter	130.3	131.5
Deck to PCADP Paros sensor	127.2	130.5
Horizontal dist between PCADP and Paros		37
Deck to PCADP OBS 1 sensor	55.2	54.5
Deck to PCADP OBS 2 sensor	90	90
Deck to ABS transmitters	136.3	138.3

2.4.2.5 Site MIB

The tripod at Site MIB was deployed with an ADV O Hydra system and imaging and profiling sonars. The data logger for the ADV O Hydra system was mounted on the upper platform of the tripod; the battery canister was mounted on a lower crossbar. The OBS were mounted on the blue leg of the tripod with OBS 1 pointing towards the green leg and OBS 2, the lower OBS, pointing towards the red leg. The data logger for the sonar was mounted on the upper platform of the tripod; the battery canister for the sonar was mounted on a lower crossbar. Figure 17 shows the approximate location of the instruments deployed during both deployments at Site MIB. The exact heights of the transducers are summarized in table 14.

All instrumentation remained the same on this tripod for both deployments and sampling schemes remained similar for both deployments. A summary of the instrument sampling parameters and serial numbers are found in table 19. For more specific information about a particular instrument see section 2.4.1.

A data logger problem resulted in the loss of numerous frames of sonar data. Cumulatively, approximately two weeks of sonar data were collected during each deployment.

The tripod at Site MIB experienced extreme biofouling during both deployments. The OBS measurements collected by the ADV O Hydra system were affected by both biofouling and the interference problem discussed previously and in appendix F.

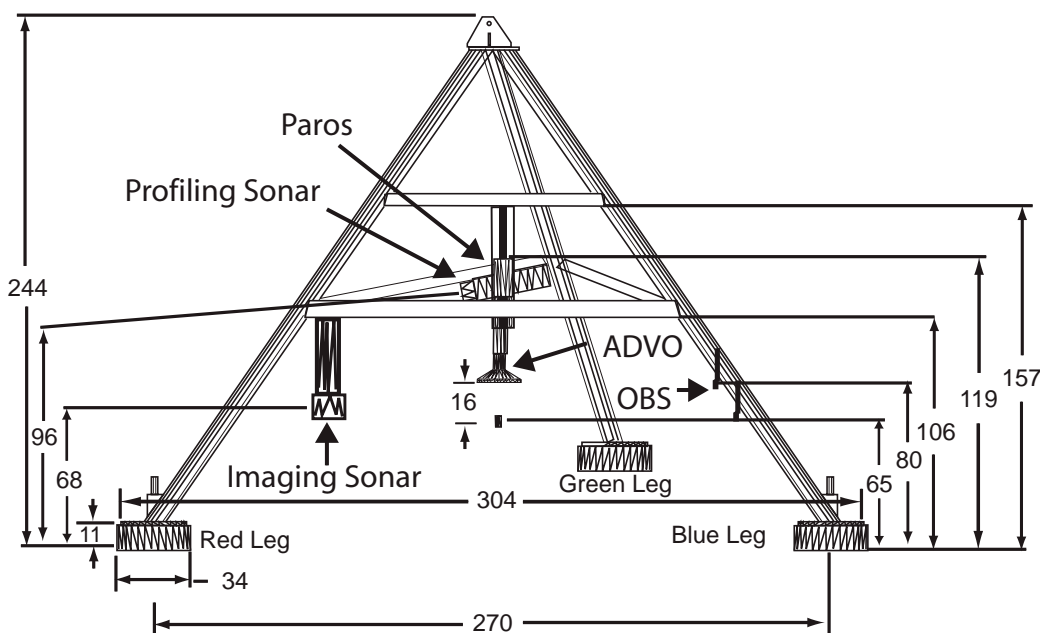


Figure 16. Schematic drawing of the tripod deployed at Site MIB. Dimensions indicated are in cm and are nominal; see table 14. ADV O—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor.

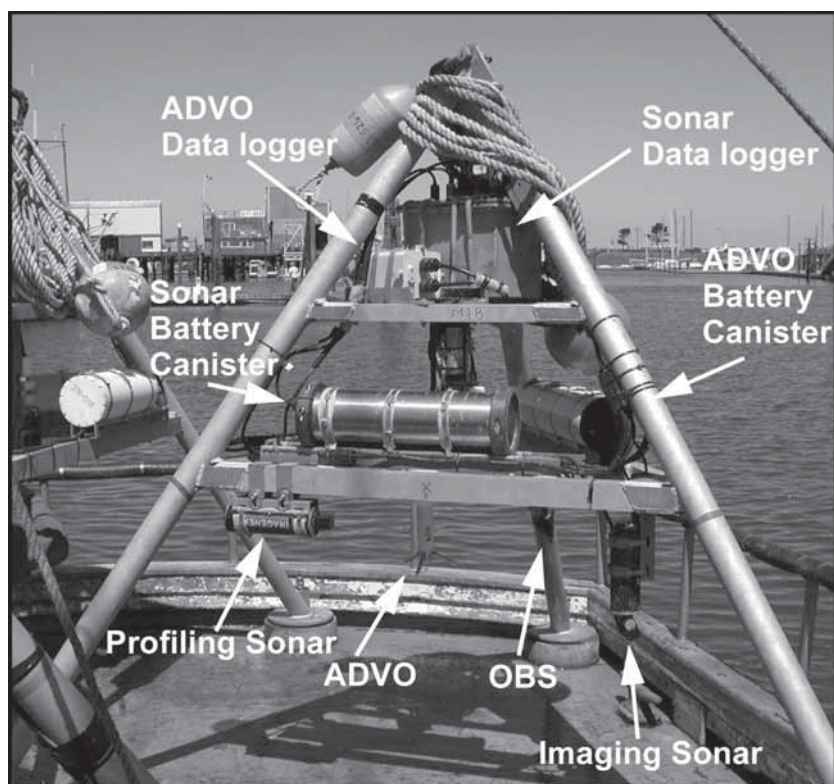


Figure 17. Photograph of the tripod deployed at Site MIB showing the pencil beam and imaging sonar system and acoustic Doppler Ocean velocimeter (ADVO) Hydra system. ADVO—acoustic Doppler velocimeter; OBS—optical backscatter sensor.

Table 19. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site MIB.

[Distances are in cm and are nominal; see table 14. (ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 1418	06/05/01 1607
Retrieval date and time	06/07/01 2158	07/11/012029
ADVO and ADV0 Hydra data logger S/N	B59	B59
ADVO Hydra Paros S/N	69181	69181
ADVO Hydra OBS1 S/N/leg mounted on/ pointing towards	1244/blue/green	1244/blue/green
ADVO Hydra OBS2 S/N/leg mounted on/ pointing towards	1429/blue/red	1429/blue/red
ADVO Hydra burst interval (s)	3,600	3,600
ADVO Hydra burst length (s)	1,200	1,200
ADVO Hydra sampling rate (Hz)	2	2
ADVO Hydra samples per burst	2,400	2,400
Sonar: Burst Period	2 hours	2 hours
Sonar: Shots per rotation	400-600	400-600
Sonar: Range	7.5 meters	7.5 meters
Sonar: Number of points per shot	2,000	2,000
Sonar: Rate	200 ksamples/sec	200 ksamples/sec
Deck to ADV0 transmitter	80.7	80.5
Deck to ADV0 Paros sensor	119	118.5
Horizontal dist between ADV0 and Paros		18
Deck to ADV0 OBS 1 sensor	79.5	79.5
Deck to ADV0 OBS 2 sensor	64.5	64.5
Deck to profile sonar transmitter	96	97
Deck to imaging sonar transmitter	67	71.5

2.4.2.6 Site SD

The tripod at Site SD was deployed with an ADP and an ADVO Hydra system. The ADP was oriented such that the legs of the tripods did not interfere with the path of the ADP beams (fig. 9). The battery canister for the ADP was mounted on a lower crossbar (fig. 10). The data logger for the ADVO Hydra system was mounted on the upper platform of the tripod while the battery canister was mounted on a lower crossbar. The OBS were mounted on the blue leg of the tripod with OBS 1 pointing towards the green leg and OBS 2, the lower OBS, pointing towards the red leg. Figure 8 shows the approximate location of the instruments deployed during both deployments at Site SD. The exact heights of the transducers during each deployment are summarized in table 14.

Instrumentation and sampling schemes remained similar for both deployments. A summary of the instrument sampling parameters and serial numbers are found in table 20. For more specific information about a particular instrument see section 2.4.1.

The tripod at Site SD experienced mild biofouling during both deployments; this biofouling affected the measurements made by OBS1 during Deployment 1. The OBS measurements collected by the ADVO Hydra system were affected by the interference problem discussed previously and in appendix F.

Table 20. Summary of deployment, retrieval, instrumentation, and sampling parameters for the tripod deployed at Site SD.

[Distances are in cm and are nominal; see table 14. (CDIP—Coastal Data Information Program; ADVO—acoustic Doppler velocimeter; Paros—Paroscientific pressure sensor; OBS—optical backscatter sensor; ADP—acoustic Doppler profiler; S/N—serial number)]

Parameter	Deployment 1	Deployment 2
Deployment date and time	05/04/01 2141	06/05/01 1701
Retrieval date and time	06/07/01 2053	07/11/01 1817
ADVO and ADVO Hydra data logger S/N	B52	B52
ADVO Hydra Paros S/N	69180	69180
ADVO Hydra OBS1 S/N/leg mounted on/ pointing towards	1243/blue/green	1243/blue/green
ADVO Hydra OBS2 S/N/leg mounted on/ pointing towards	1428/blue/red	1428/blue/red
ADVO Hydra burst interval (s)	3,600	3,600
ADVO Hydra burst length (s)	1,200	1,200
Sampling rate (Hz)	2	2
Samples per burst	2,400	2,400
ADP S/N	C132	C132
Druck calibration filename	995410.drk	995410.drk
Profile Interval (s)	1,800	1,800
Averaging Interval (s)	600	600
Deck to ADVO transmitter	95.7	95.5
Deck to ADVO Paros sensor	117	116.5
Horizontal dist between ADVO and Paros		18.5
Deck to ADVO OBS 1 sensor	79.5	80
Deck to ADVO OBS 2 sensor	60.5	60.5
Deck to top of ADP	195.5	195

2.5 Morphology Measurements

2.5.1 Overview

A beach monitoring program was initiated on March 29, 2001, to monitor morphological change during the spring experiment. The monitoring program was modeled after the program

used by the SWCES in the CRLC that began during the summer of 1997 (Ruggiero and others, 1998 and 1999; Ruggiero and Voigt, 2000; Ruggiero and others, in press).

The field program was designed to document seasonal scale morphological change over the nearshore planform within 4 km of the Grays Harbor North Jetty. Monitoring was conducted using real-time kinematic differential Global Position System (RTK DGPS) survey methods that combine both high accuracy and speed of measurement (Morton and others, 1993). Sampling methods resolved alongshore length scales of ~10 m to ~4 km and cross-shore length scales of ~1 m to ~2 km.

Components of the monitoring program include:

- Topographic beach profiles,
- Topographic beach surface maps, and
- Nearshore bathymetry.

2.5.2 Topographic Beach Profiles

Topographic beach profiles were typically collected along 6 cross-shore beach profile lines spaced at 1 km intervals from 4 km north of the Grays Harbor North Jetty to approximately 10 km north of the North Jetty (fig. 4; table 21). The profile lines were oriented in an east-west direction so as to be aligned with the nearshore bathymetry transects previously collected by the SWCES.

2.5.2.1 Field Equipment

Field equipment for topographic beach profiles consists of a RTK DGPS base station and an RTK DGPS rover. The base station consists of a Trimble 4000 series receiver, a Trimble non-micro centered T1/T2 GPS antenna with a ground plane, a Pacific Crest UHF radio modem, radio antenna, two tripods, and various cables. The rover consists of a Trimble 4000 series GPS receiver, a Trimble micro centered T1/T2 GPS antenna, Pacific Crest radio modem, radio antenna, a Trimble TDC1 or TSC1 data logger, and various cables mounted to a backpack.

2.5.2.2 Field Procedures and Accuracy

An RTK DGPS base station is set up on or near a control monument of the Washington Coastal Geodetic Control Network (Daniels and others, 1999). The GPS antenna is mounted on a tripod that is leveled over a known monument or a small board placed on the ground (fig. 18). Once leveled, the tripod is secured with sand bags and the antenna is connected to the GPS receiver via a data cable. The radio modem and antenna are attached to the second tripod and connected to the GPS receiver via a data cable. After all connections have been made, the Trimble 4000 series receiver is started using a handheld data logger and the radio modem is turned on. Beach profiles are measured by walking with the rover unit from the landward edge of the primary dune, over the dune crest, to wading depth at spring low tide (fig. 19). Two to three calibration points per survey are collected for subsequent field calibration, ensuring consistency with the Washington Coastal Geodetic Control Network.

The methodology used in the monitoring program can reliably detect beach elevation change greater than approximately 8-cm (Ruggiero and others, in press). While not as accurate as standard terrestrial surveying using a rod and level, walking the profiles with a GPS backpack is justified by both the reduction in survey time and the large seasonal changes observed on the high-energy beaches of the CRLC. Following final quality assurance and quality control (QA/QC; Ruggiero and others,

in press) data are reported as x, y, z triplets (easting, northing, elevation) with the horizontal datum Washington State Plane South NAD 83 m and the vertical datum NAVD 88 m. Each transect has a file name of the form nb_date_line#_t.xyz.

Table 21. Start and end points of lines used for Coastal Profiling System (CPS) bathymetry and topographic beach profile collection.

Profile No.	Start Easting (m)	Start Northing (m)	End Easting (m)	End Northing (m)	Start Longitude	Start Latitude	End Longitude	End Latitude
1	218154.4	183798.8	219892.0	183802.2	124° 12.15'	46° 55.65'	124° 10.77'	46° 55.68'
2	218215.2	184008.0	219920.0	184003.3	124° 12.10'	46° 55.77'	124° 10.77'	46° 55.80'
3	218271.1	184206.8	220092.8	184201.8	124° 12.07'	46° 55.87'	124° 10.63'	46° 55.92'
4	218222.4	184408.7	220030.1	184400.7	124° 12.12'	46° 55.97'	124° 10.68'	46° 56.02'
5	218493.3	184599.3	219913.5	184601.5	124° 11.90'	46° 56.08'	124° 10.78'	46° 56.12'
6	218341.3	184795.2	219976.1	184801.2	124° 12.03'	46° 56.18'	124° 10.75'	46° 56.23'
7	218471.1	184989.5	219987.6	184993.4	124° 11.93'	46° 56.30'	124° 10.75'	46° 56.33'
8	218593.4	185194.6	219998.1	185190.7	124° 11.85'	46° 56.40'	124° 10.75'	46° 56.43'
9	218523.7	185390.9	219987.7	185402.3	124° 11.92'	46° 56.52'	124° 10.75'	46° 56.55'
10	218334.7	185591.9	219951.0	185576.7	124° 12.07'	46° 56.62'	124° 10.80'	46° 56.65'
11	218413.3	185793.2	219948.7	185795.6	124° 12.02'	46° 56.73'	124° 10.80'	46° 56.77'
12	217772.3	186007.8	219977.3	185990.8	124° 12.52'	46° 56.83'	124° 10.78'	46° 56.87'
13	217603.8	186202.3	220051.7	186196.7	124° 12.67'	46° 56.93'	124° 10.73'	46° 56.98'
14	217979.4	186400.8	220157.3	186394.0	124° 12.38'	46° 57.05'	124° 10.67'	46° 57.10'
15	217957.4	186603.7	220171.0	186596.2	124° 12.40'	46° 57.15'	124° 10.65'	46° 57.20'
16	217993.6	186794.7	220180.7	186792.4	124° 12.38'	46° 57.25'	124° 10.65'	46° 57.32'
17	217800.9	186989.9	220187.4	186970.3	124° 12.53'	46° 57.35'	124° 10.65'	46° 57.40'
18	218011.2	187191.2	220051.3	187194.0	124° 12.38'	46° 57.47'	124° 10.77'	46° 57.52'
19	218025.0	187399.2	220067.8	187400.9	124° 12.38'	46° 57.58'	124° 10.77'	46° 57.63'
20	218024.3	187592.8	220076.9	187593.6	124° 12.38'	46° 57.68'	124° 10.77'	46° 57.73'
25	218645.9	188597.0	220252.8	188596.9	124° 11.93'	46° 58.25'	124° 10.67'	46° 58.28'
30	218208.2	189602.3	220215.8	189601.7	124° 12.32'	46° 58.77'	124° 10.73'	46° 58.82'
35	218292.8	190601.4	220233.0	190599.5	124° 12.28'	46° 59.32'	124° 10.75'	46° 59.37'
40	218597.6	191607.9	220406.9	191599.7	124° 12.08'	46° 59.87'	124° 10.65'	46° 59.90'
45	218725.0	192604.7	220525.3	192603.0	124° 12.02'	47° 0.40'	124° 10.60'	47° 0.45'
50	218612.3	193599.0	220485.9	193602.3	124° 12.15'	47° 0.93'	124° 10.67'	47° 0.98'

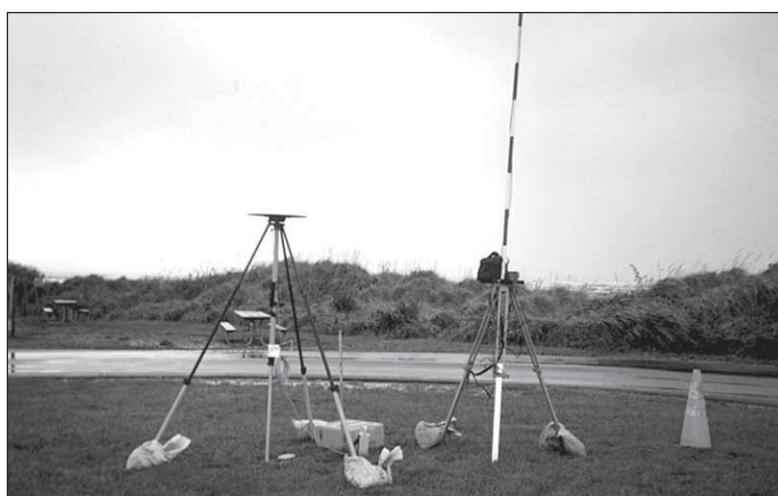


Figure 18. Example setup of GPS equipment. The disc antenna on the tripod (left) receives data from satellites while the antenna on the right transmits this information to a rover receiver collecting data on the beach.

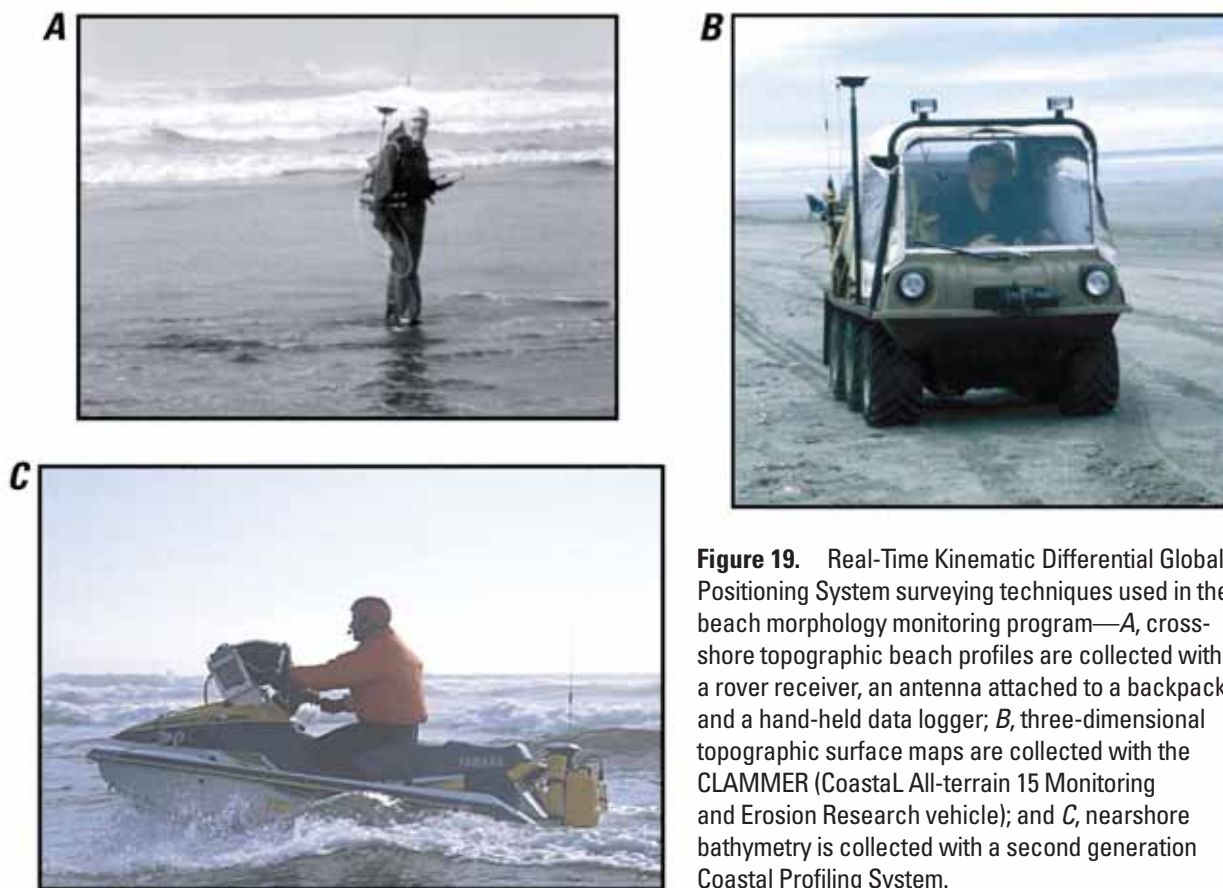


Figure 19. Real-Time Kinematic Differential Global Positioning System surveying techniques used in the beach morphology monitoring program—*A*, cross-shore topographic beach profiles are collected with a rover receiver, an antenna attached to a backpack, and a hand-held data logger; *B*, three-dimensional topographic surface maps are collected with the CLAMMER (CoastaL All-terrain 15 Monitoring and Erosion Research vehicle); and *C*, nearshore bathymetry is collected with a second generation Coastal Profiling System.

2.5.3 Topographic 3-D Beach Surface Maps

Although analyses of beach profiles can reveal the cross-shore variability in beach change, little information about the alongshore component of beach change can be extracted from this data. Therefore, three-dimensional topographic beach surface maps were generated in lieu of multiple closely-spaced cross-shore transects for the region extending from the Grays Harbor North Jetty to 4 km to the north.

2.5.3.1 Field Equipment

Field equipment for surface maps consists of an RTK DGPS base station, an RTK DGPS rover, and an amphibious all-terrain vehicle. The base station setup is identical to that used for the beach profiles. The rover consists of a Trimble 4700 GPS receiver, a Trimble micro centered T1/T2 GPS antenna, Pacific Crest radio modem, radio antenna, a Trimble TDC1 or TSC1 data logger, and various cables mounted to a six-wheel drive amphibious all-terrain vehicle called the CLAMMER (CoastaL All-terrain 15 Monitoring and Erosion Research Vehicle). The CLAMMER is a model MAX IV vehicle made by Recreatives Industries Inc. It was chosen as our survey vehicle because of its all-terrain and amphibious capabilities as well as the vehicle's low weight to tire size ratio. The weight distribution is important because while surveying at low tide the CLAMMER is often driven over Razor clam beds that are sensitive to pressure. The MAX IV manufacturer reports that the vehicle applies less pressure on the ground than a human footprint, causing minimal damage to invertebrate populations.

2.5.3.2 Field Procedures and Accuracy

The RTK DGPS base station is set up in a similar fashion as for collecting beach profiles (fig. 18).

Surface map data are stored onboard the CLAMMER using a Trimble TSC1 data logger. The surface map is approximately 4 km in length and hundreds of meters in width, spanning the area between the toe of the primary dune and the swash zone (fig. 19; table 22). The CLAMMER, traveling along the beach at approximately 6 m/s collects individual point measurements every 5 to 10 m. Individual point measurements are densely spaced in the alongshore direction to resolve relatively small-scale features such as beach cusps. The cross-shore distance between alongshore transects is typically 20 to 30 m but is determined in the field based on cross-shore breaks in beach slope, such as at crests and troughs of swash bars and sand berms. The surveys extend over long enough distances to resolve larger scale, potentially migrating features such as mega-cusps, rip-current embayments, and sand waves.

The methodology used in collecting topographic beach surface maps can only reliably detect vertical beach elevation change greater than approximately 10 cm (Ruggiero and others, in press). Following final QA/QC the raw data points are exported to individual ASCII text files. Data are reported as x, y, z triplets (easting, northing, elevation) with the horizontal datum Washington State Plane South NAD 83 m, and the vertical datum NAVD 88 m (for example, os_map_date.out). The nonuniformly spaced raw data (typically 5,000 to 10,000 points) are also mapped onto a uniform 2-dimensional gridded surface via triangle-based, weighted linear interpolation, allowing for comparison with subsequent data sets. Cross-shore transects are extracted from gridded three-dimensional surface maps at the alongshore locations of the nearshore bathymetric transects. Each transect is given a file name of the form nb_date_line#_t.xyz.

Table 22. Corner points for the Ocean Shores surface map.

Upper Right Corner				Lower Left Corner			
Easting (m)	Northing (m)	Latitude	Longitude	Easting (m)	Northing (m)	Latitude	Longitude
220249.0	187583.0	46° 57.73'	124° 10.63'	220105.0	183657.0	46° 55.62'	124° 10.60'

2.5.4 Nearshore Bathymetry

The subaerial, or visible, beach comprises only a portion of the active coastal zone. Variability in subaqueous beach morphology can influence the amount of energy from waves that is available to impact the shoreline and cause beach change. It has historically been very difficult and expensive to collect data in this highly dynamic region and only a few coastlines in the world have sufficient nearshore data to quantify this variability. The Coastal Profiling System (CPS), a hydrographic surveying system mounted on a Personal Watercraft (PWC), originally designed at Oregon State University (Beach and others, 1996; Côté, 1999; MacMahan, 2001) to collect data in energetic nearshore environments, was used in the spring 2001 experiment.

2.5.4.1 Field Equipment

The CPSII (2nd generation Coastal Profiling System), cooperatively designed with the University of Florida (MacMahan, 2001), consists of a personal watercraft equipped with a GPS receiver and antenna, an echo sounder, and computer running hydrographic survey software (fig. 19). Modifications to the original system include (1) a monitor for visual aid, (2) an echo sounder with a

higher sampling frequency, (3) a keypad for operator control, and (4) surveying software for navigation, data collection, and data analysis (MacMahan, 2001).

The PWC used for the CPSII was a 1998 3-man Yamaha Venture 700 wave runner chosen because of its stability, compartment space, and relatively low price. The 3-man PWC measures 3.15 m in length, 1.25 m in width, and 1.05 m in height. During normal surveying operation, the wave runner travels at approximately 3 m/s (5 knots) and can operate for approximately 3 to 5 hours on one 50-L fuel tank. The instruments are placed in the compartment space located under the back seat, on a bracket at the stern on the vessel, and on brackets in the forward part of the vessel in front of the handlebars. In the storage space under the rear seat of the PWC, a small platform (false bottom) was mounted with a small watertight case located on the underside. This case holds a DC-DC converter and an in-line fuse. On the topside of the platform are two larger watertight cases that house the GPS, computer, and echo sounder electronics. The echo sounder and the laptop computer are mounted in the computer case. This case has six external watertight connectors—one is for serial communication with the GPS, one for the echo sounder transducer, one for the external screen, one for the external 17 button keypad, one for power, and one spare. The complete system is powered by two gel cell 12-volt marine batteries, configured in series and housed in a Pelican box mounted on the bracket at the stern of the PWC. The system draws approximately 24 volts at approximately 2.8 amps (MacMahan, 2001).

Horizontal and vertical positioning of the CPSII is obtained using a Trimble 4700 GPS receiver, which is enclosed in a waterproof Pelican box stowed in the storage compartment underneath the seat. Within the GPS case also resides the GPS radio modem (Pacific Crest) that is used to communicate with the shore base station. A small A-frame is attached to the topside stern of the vessel for mounting the GPS antenna and the radio antenna. The GPS antenna is mounted approximately 90 cm directly above the echo sounder transducer.

The echo sounder on boat 1 is a Bathy-500 single-frequency echo sounder with a 208 kHz transducer manufactured by Ocean Data Equipment Corporation (ODEC). The echo sounder on boat 2 is a Bathy-500 MF (multiple frequency) from ODEC. These echo sounders have adjustable gains, offset, serial outputs, and speed of sound control. The sampling rate is a function of water depth with the highest sampling rate of 8 Hz applied in shallow water (0-10 m). The resolution of the echo sounders is approximately 3 cm. The transducers have a conical beam width of 10 and 8 degrees, boat 1 and boat 2 respectively, and generate a pulse at 208 kHz. The echo sounder transducer is mounted just below the engine jet on a removable plate on the underside of the vessel at the stern. It is located 29.2 cm below the waterline of the unmanned wave runner.

The electronics of the echo sounder were reconfigured and along with the laptop computer (Palmax Pen Computer - 266MHz, Pentium, Windows 98), placed in a watertight Pelican Case. The CPSII collects data at 5 Hz and while traveling at 3 m/s generates a depth sounding approximately every 0.6 meters along the sea floor.

HYPACK (Coastal Oceanographics, Inc.) hydrographic surveying software is used as the data synchronization software and navigation system. Hypack allows visual observation of trackline, distance offline, depth, latitude, longitude, easting, northing, corrected depth, filename, line number, satellite quality, number of satellites, collection mode, and recording mode. All of this information is useful to the operator when collecting hydrographic data.

Navigation and surveying are aided by the use of a monitor (a 25.4 cm (10 inch) Computer Dynamics VAMP 1000 daylight readable screen with 900 NIT reading), which is mounted in a watertight case on a bracket forward of the handlebars. A retractable bellows is mounted onto the screen case, sheltering the screen from direct sunlight to allow better viewing of the external monitor that shows the real-time surveying data. A small 17-button programmable Logic Controls keypad (24 cm X 8.9 cm X 3.2 cm) is placed in a waterproof radio bag mounted on the handlebars.

2.5.4.2 Field Procedures and Accuracy

As HYPACK allows for surveying within a user-defined coordinate system, in this case NAD83 Washington State Plane (4602) South and NAVD88; collecting land-based control points is not necessary with the CPSII. The GPS base station is set up over a known survey monument within the Coastal Geodetic Control Network (Daniels and others, 1999) and survey accurate data is stored in HYPACK in the appropriate datum.

Another significant improvement with the CPSII is the ability to survey preset track lines, eliminating the need for range poles on the beach. Data is collected only when the PWC operator selects a line. The PWC operator maneuvers the vessel offshore to either a target depth (typically around 12 m) or a target easting (table 21). Each profile extends from a deep-water limit ranging between 10 and 16 m (MSL) toward the shoreline, where the operator ends the line in a water depth of approximately 1 m.

Several QA/QC steps ensure data fidelity; however, a conservative estimate of the total vertical uncertainty for these nearshore bathymetry measurements is approximately 0.15 m (Ruggiero and others, in press). The data files presented on DVD01 have been run through a preprocessing Perl script, the HYPACK editor, corrected for vertical offsets, speed of sound and salinity, and smoothed, and are considered the final 'processed' data files. They are reported as x, y, z triplets (easting, northing, elevation) with the horizontal datum Washington State Plane South NAD 83 m, and the vertical datum NAVD 88 m. Each transect has a file name of the form nb_date_line#_b.xyz.

DATA

3.1 Surface Sediment Samples

The grain-size distributions of the surface sediment samples collected during the experiment were determined using standard USGS Coastal and Marine Geology procedures, modified from Folk (1968) and Carver (1971, chapter 4). Settling tubes (modified after Thiede and others, 1976, and similar to those described by Syvitski, 1991, chapters 1 and 4) were used to analyze the sand fraction (4 phi to -1 phi, 0.063 mm to 2 mm). The weight percentage of the fine (> 4 phi, < 0.063 mm) fraction was determined. Analysis of the fine fraction was performed on samples containing more than 2 percent fines (samples ND, MD, 514, 544, and 534) using a Coulter LS Particle Size Analyzer (Coulter Corp., 1994). Otherwise, no further analysis of the fine fraction was performed. The samples contained no coarse (< -1 phi, > 2 mm) fraction.

Statistical analyses of the results were obtained using the USGS-developed computer program, SDSZ. The program calculates the statistics of the distribution—median, mean, skewness, and kurtosis—using several methods, such as the various graphical methods presented by Folk and Ward, Inman (Carver, 1971, chapter 6), and Trask (1930), as well as the moment measures (Carver, 1971, chapter 6).

The results of grain-size analyses (weight percent in 1/4-phi intervals) are listed tables 23, 25, and 27 and graphed in figs. 20, 21, 22, and 23. Settling velocity has been calculated using the Gibbs and others (1971) equation for settling velocity at 10°C, 30 psu, and 18 dbar.

All the samples collected during the experiment, with the exceptions of ND (fig. 3) and 541 (fig. 4) were very well sorted fine sands, with means of 2.53 to 2.86 phi (0.14 to 0.17 mm) and sortings of 0.20 to 0.34 phi (Folk, 1968). Sediment from Site ND was a moderately sorted fine sand with a mean size of 2.66 phi (0.16 mm) and sorting of 0.72 phi. Sediment sample 541 was a moderately well sorted fine sand with a mean size of 2.06 phi (0.24 mm), with a sorting of 0.59 phi. Each sample contained no coarse fraction and relatively little fine fraction (< 7 percent). Statistical descriptions of each sediment sample are reported in tables 24, 26, and 28.

Table 23. Results of grain size analysis reported as weight percent at 1/4 phi intervals (with associated settling velocity) for samples collected on May 4, 2001, from aboard the F/V *Tricia Rae* at instrument deployment sites.

phi class	Settling Velocity (cm/s)	ND	MD	MS	MI	SD
-1.00	2.653E+01	0.00	0.00	0.00	0.00	0.00
-0.75	2.307E+01	0.00	0.00	0.00	0.00	0.00
-0.50	1.992E+01	0.00	0.00	0.00	0.00	0.00
-0.25	1.708E+01	0.00	0.00	0.00	0.00	0.00
0.00	1.453E+01	0.00	0.00	0.00	0.00	0.00
0.25	1.225E+01	0.00	0.00	0.49	0.00	0.00
0.50	1.024E+01	0.00	0.00	0.00	0.00	0.00
0.75	8.474E+00	0.00	0.00	0.00	0.00	0.00
1.00	6.937E+00	0.00	0.00	0.00	0.00	0.00
1.25	5.612E+00	1.89	0.00	0.49	0.00	0.00
1.50	4.485E+00	2.83	0.00	0.99	0.00	0.00
1.75	3.537E+00	5.66	0.00	0.99	0.98	0.00
2.00	2.751E+00	8.49	0.00	2.97	0.98	0.00
2.25	2.111E+00	11.79	0.95	6.93	3.93	0.99
2.50	1.598E+00	6.60	6.17	14.85	9.83	4.94
2.75	1.194E+00	11.79	24.19	41.57	26.30	26.20
3.00	8.821E-01	25.47	45.54	27.22	53.35	49.44
3.25	6.452E-01	8.49	10.44	0.49	2.46	9.39
3.50	4.681E-01	4.91	3.06	0.49	0.00	4.94
3.75	3.373E-01	3.31	3.25	0.49	0.00	0.99
4.00	2.419E-01	2.19	2.04	0.99	0.00	0.99
4.25	1.728E-01	3.19	1.19	0.00	0.49	0.99
4.50	1.231E-01	0.69	0.70			
4.75	8.748E-02	0.46	0.52			
5.00	6.209E-02	0.35	0.40			
5.25	4.402E-02	0.23	0.23			
5.50	3.119E-02	0.15	0.13			
5.75	2.208E-02	0.20	0.15			
6.00	1.563E-02	0.13	0.09			
6.25	1.106E-02	0.11	0.08			
6.50	7.823E-03	0.06	0.05			
6.75	5.533E-03	0.12	0.09			
7.00	3.914E-03	0.07	0.06			
7.25	2.768E-03	0.07	0.06			
7.50	1.957E-03	0.05	0.04			
7.75	1.384E-03	0.09	0.08			
8.00	9.788E-04	0.06	0.05			
8.25	6.922E-04	0.06	0.05			
8.50	4.894E-04	0.06	0.05			
8.75	3.461E-04	0.06	0.05			
9.00	2.447E-04	0.05	0.04			
9.25	1.731E-04	0.06	0.05			
9.50	1.224E-04	0.04	0.04			
9.75	8.653E-05	0.04	0.03			
10.00	6.118E-05	0.05	0.04			
11.25	1.082E-05	0.13	0.11			
14.00	2.390E-07	0.00	0.00	1.03	1.66	1.12

The sediment sample collected at Site ND during the Grays Harbor Wave Refraction Experiment 1999 also appeared to be slightly coarser and less well sorted than other deep water sites. Side-scan sonar and multibeam backscatter data (Twichell and others, 2000; R. Flood, oral commun., 1999) suggest that gravel patches with abrupt boundaries exist in several locations within the study area. The sediment sample at Site ND was taken close to a gravel patch, which may account for the coarser, more poorly sorted sediment found at that site.

Sediment sample 541 was collected next to the north side of the Grays Harbor North Jetty. This sample is likely a lag deposit. Sediment can become coarser near the jetty as the finer sediment is winnowed by shoaling waves and persistent offshore currents next to the jetty.

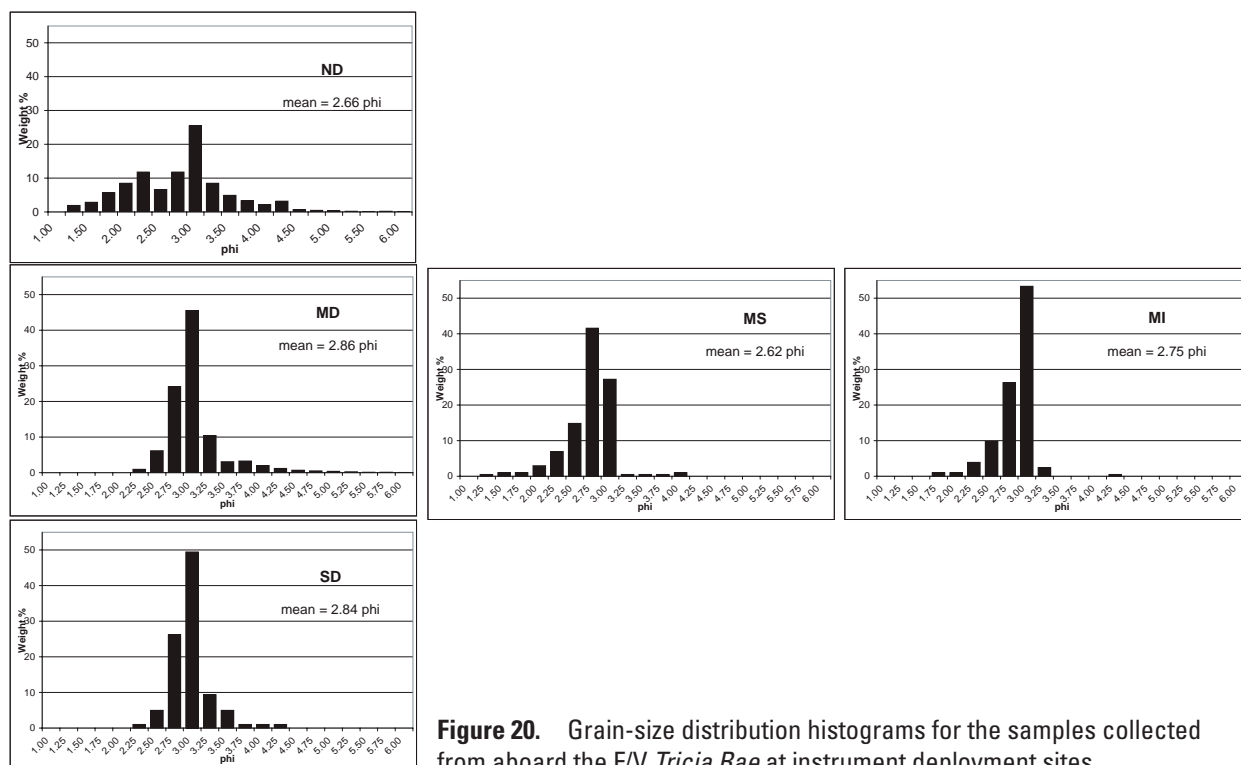


Figure 20. Grain-size distribution histograms for the samples collected from aboard the F/V *Tricia Rae* at instrument deployment sites.

Table 24. Results of grain-size statistical analysis (in phi unless otherwise noted) for samples collected from aboard the F/V *Tricia Rae* at instrument deployment sites on May 4, 2001.

Site	ND	MD	MS	MI	SD
% Gravel	0.00	0.00	0.00	0.00	0.00
% Sand	93.43	95.63	98.97	97.84	97.89
% Silt	6.02	3.91	0.40	1.13	1.42
% Clay	0.55	0.46	0.64	1.02	0.69
% Mud	6.57	4.37	1.03	2.16	2.11
Moment measures:					
1st moment	2.73	2.97	2.65	2.82	2.93
Variance	0.90	0.47	0.59	0.75	0.52
Std. deviation	0.95	0.68	0.77	0.86	0.72
3rd moment	2.65	5.57	5.95	6.41	7.18
4th moment	18.58	47.50	53.47	47.32	61.61
Folk and Ward:					
Median	2.76	2.79	2.67	2.79	2.75
Mean	2.66	2.86	2.62	2.75	2.84
Sorting	0.72	0.34	0.30	0.22	0.23
Skewness	-0.10	0.48	-0.29	-0.37	0.54
Kurtosis	1.16	2.61	1.26	1.08	1.59
Inman:					
Median	2.76	2.79	2.67	2.79	2.75
Mean	2.61	2.89	2.60	2.73	2.88
Sorting	0.68	0.23	0.28	0.22	0.17
Skewness 1	-0.22	0.46	-0.22	-0.28	0.73
Skewness 2	0.03	1.65	-0.67	-0.78	0.98
Kurtosis	0.85	2.29	0.81	0.65	1.76
Trask (mm):					
Median	0.15	0.14	0.16	0.14	0.15
Mean	0.18	0.14	0.16	0.15	0.14
Sorting	1.36	1.08	1.12	1.10	1.09
Skewness	1.30	0.90	1.04	1.03	0.93
Kurtosis	0.24	0.14	0.20	0.33	0.21

Table 25. Results of grain size analysis reported as weight percent at 1/4 phi intervals (with associated settling velocity) for samples collected from aboard the Coastal Profiling System (CPS).

phi class	Settling Velocity (cm/s)	502	505	513	514	541	542	543	544	610	512	511	525	536	535	534	609	608	602
-1.00	2.653E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.75	2.307E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.50	1.992E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.25	1.708E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.453E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1.225E+01	0.00	1.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.50	1.024E+01	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
0.75	8.474E+00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
1.00	6.937E+00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00
1.25	5.612E+00	0.00	0.00	0.50	0.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.50	0.00	0.50	0.00	0.00
1.50	4.485E+00	0.00	1.00	0.50	0.00	7.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	2.00	1.50	0.00	0.50	0.00	0.50
1.75	3.537E+00	1.00	0.00	0.99	0.00	9.50	0.50	0.99	0.00	1.00	0.00	0.50	0.00	2.99	2.00	0.00	2.49	1.00	1.99
2.00	2.751E+00	1.99	0.50	3.96	0.47	11.00	1.98	0.99	0.97	1.00	0.00	0.5	0.99	5.49	3.50	0.48	3.49	3.50	2.48
2.25	2.111E+00	5.48	6.47	8.92	2.85	12.50	3.47	3.46	2.43	3.00	1.49	2.99	2.47	9.98	5.50	1.93	8.48	5.00	6.95
2.50	1.598E+00	17.43	14.44	22.30	9.96	19.50	12.4	9.90	7.79	9.00	5.95	9.48	8.41	29.43	16.00	8.22	17.96	15.00	16.39
2.75	1.194E+00	47.80	41.34	45.10	63.56	23.00	29.27	26.23	33.58	31.00	38.68	29.94	27.69	42.40	44.00	20.79	36.41	36.00	43.20
3.00	8.821E-01	24.89	32.87	13.88	17.08	5.50	43.66	48.49	46.24	49.50	50.58	49.90	49.45	5.49	23.50	61.90	24.44	35.00	25.32
3.25	6.452E-01	0.50	1.49	2.97	0.95	0.00	6.95	6.93	6.33	4.00	2.48	4.49	8.41	1.00	1.50	1.93	1.50	3.50	0.99
3.50	4.681E-01	0.50	0.50	0.00	0.13	0.00	0.50	0.49	0.04	0.50	0.00	0.50	0.00	0.00	1.00	0.57	1.00	0.50	0.50
3.75	3.373E-01	0.00	0.00	0.00	0.17	0.00	0.50	0.49	0.09	1.00	0.00	1.50	1.48	0.00	0.00	0.12	0.00	0.50	0.00
4.00	2.419E-01	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.21	1.00	0.00	0.99
4.25	1.728E-01	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00		1.27	0.00		0.00
4.50	1.231E-01				0.45				0.26							0.38			
4.75	8.748E-02				0.46				0.25							0.39			
5.00	6.209E-02				0.48				0.26							0.38			
5.25	4.402E-02				0.40				0.21							0.29			
5.50	3.119E-02				0.29				0.14							0.19			
5.75	2.208E-02				0.40				0.19							0.21			
6.00	1.563E-02				0.27				0.12							0.12			
6.25	1.106E-02				0.22				0.10							0.09			
6.50	7.823E-03				0.12				0.05							0.04			
6.75	5.533E-03				0.21				0.09							0.08			
7.00	3.914E-03				0.11				0.05							0.04			
7.25	2.768E-03				0.09				0.05							0.04			
7.50	1.957E-03				0.06				0.03							0.02			
7.75	1.384E-03				0.10				0.05							0.04			
8.00	9.788E-04				0.06				0.03							0.03			
8.25	6.922E-04				0.05				0.03							0.03			
8.50	4.894E-04				0.06				0.03							0.02			
8.75	3.461E-04				0.05				0.03							0.02			
9.00	2.447E-04				0.05				0.02							0.02			
9.25	1.731E-04				0.05				0.03							0.03			
9.50	1.224E-04				0.04				0.02							0.02			
9.75	8.653E-05				0.04				0.02							0.02			
10.00	6.118E-05				0.05				0.03							0.02			
11.25	1.082E-05				0.12				0.06							0.06			
14.00	2.390E-07	0.42	0.39	0.88			0.77	1.03			0.83	0.21	1.11	0.23	0.00		0.25	0.00	0.69

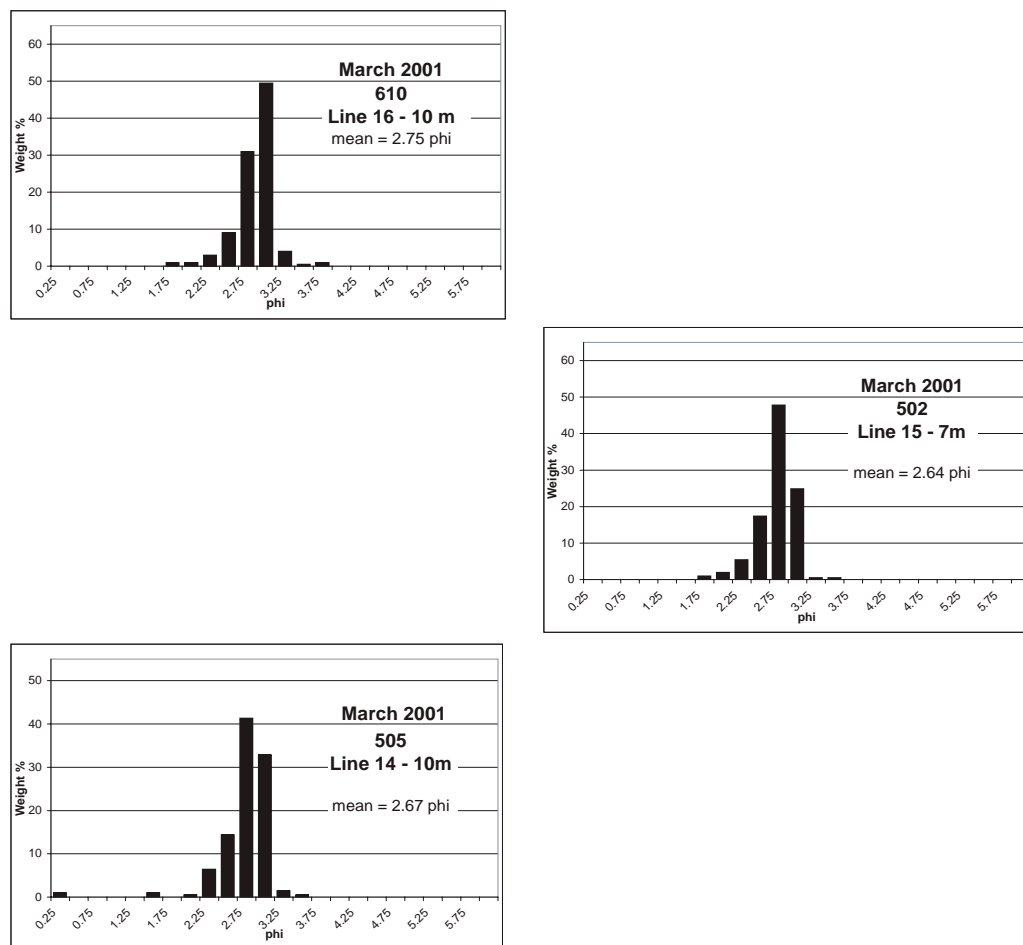


Figure 21. Histograms showing the grain size distribution of the sediment samples collected in March 2001 at Line 16 at 10 meters water depth (sample number 610), Line 15 at 7 m water depth (sample number 502), and Line 13 at 10 m water depth (sample number 505) from aboard the Coastal Profiling System (CPS).

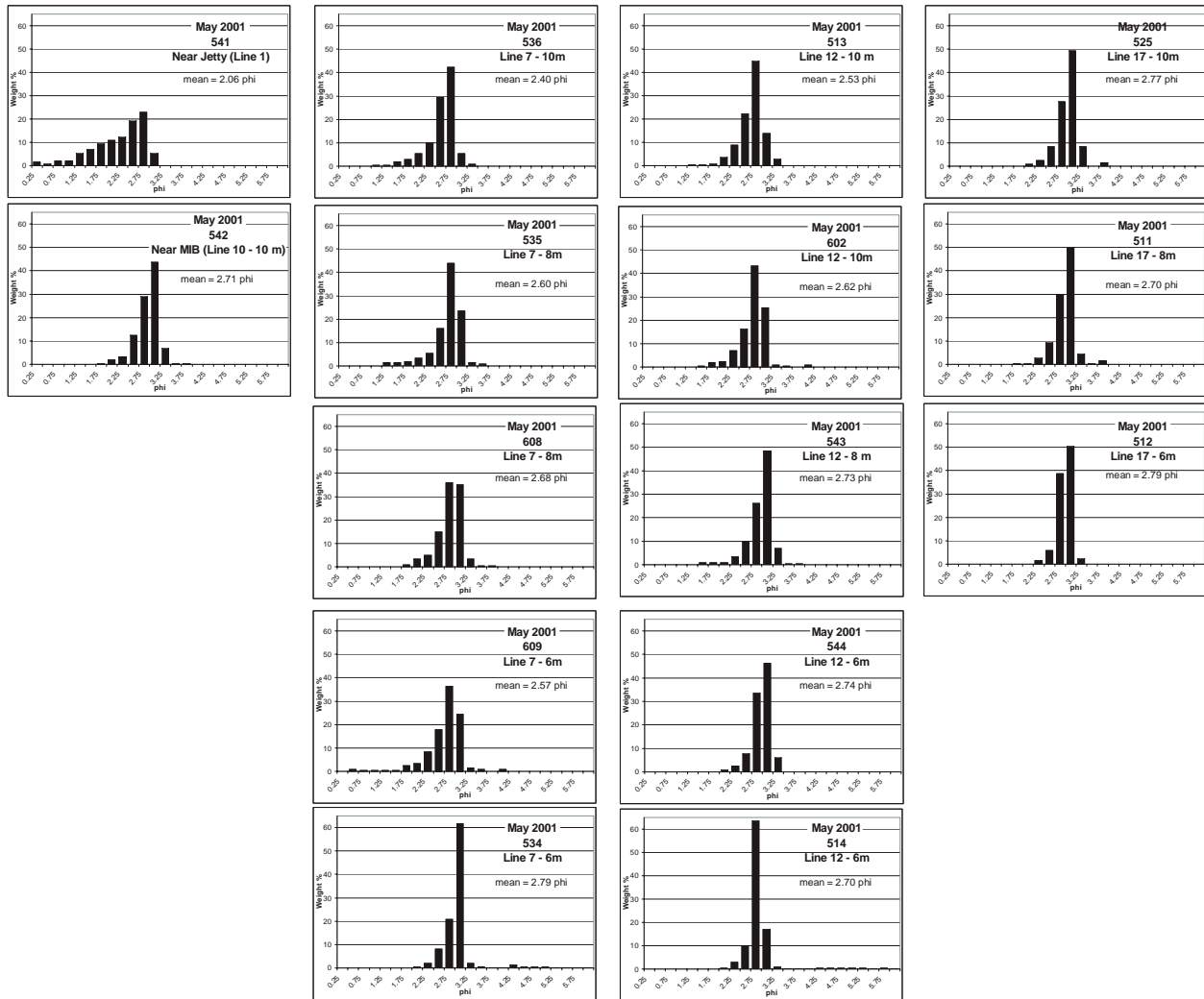


Figure 22. Histograms showing the grain size distributions of the samples collected in May 2001 from the Coastal Profiling System (CPS) within the area of bathymetric profile lines 1 to 20.

Table 26. Results of grain-size statistical analysis (in phi unless otherwise noted) for samples collected from aboard the Coastal Profiling System (CPS).

Site	502	505	513	514	541	542	543	544	610	512	511	525	536	535	534	609	608	602
% Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Sand	99.58	99.61	99.12	95.43	100.00	99.23	98.97	97.63	100.00	99.17	99.79	98.89	99.77	100.00	96.16	99.75	100.00	99.31
% Silt	0.16	0.15	0.34	4.07	0.00	0.30	0.40	2.09	0.00	0.32	0.08	0.43	0.09	0.00	3.60	0.10	0.00	0.27
% Clay	0.26	0.24	0.54	0.50	0.00	0.47	0.64	0.28	0.00	0.51	0.13	0.68	0.14	0.00	0.24	0.15	0.00	0.42
% Mud	0.42	0.39	0.88	4.57	0.00	0.77	1.03	2.37	0.00	0.83	0.21	1.11	0.23	0.00	3.84	0.25	0.00	0.69
Moment measures:																		
1st moment	2.63	2.63	2.58	2.78	2.04	2.76	2.79	2.81	2.73	2.80	2.76	2.84	2.42	2.54	2.86	2.54	2.64	2.63
Variance	0.24	0.30	0.47	0.59	0.39	0.39	0.51	0.33	0.07	0.37	0.15	0.51	0.23	0.14	0.32	0.32	0.09	0.40
Std. deviation	0.49	0.55	0.69	0.76	0.62	0.63	0.72	0.57	0.27	0.61	0.39	0.71	0.48	0.37	0.57	0.56	0.30	0.63
3rd moment	9.45	5.45	7.45	5.57	-0.96	7.97	7.02	6.81	-0.92	9.43	8.90	7.58	5.94	-1.56	6.21	2.97	-0.76	7.43
4th moment	126.89	83.00	72.68	40.72	3.43	82.48	63.91	68.23	6.57	99.03	149.6	67.59	94.29	6.35	60.10	50.04	4.47	78.05
Folk and Ward:																		
Median	2.65	2.70	2.54	2.72	2.21	2.76	2.79	2.78	2.78	2.77	2.78	2.80	2.50	2.64	2.82	2.61	2.70	2.65
Mean	2.64	2.67	2.53	2.70	2.06	2.71	2.73	2.74	2.75	2.79	2.70	2.77	2.40	2.60	2.79	2.57	2.68	2.62
Sorting	0.24	0.23	0.27	0.26	0.59	0.24	0.24	0.20	0.22	0.14	0.18	0.22	0.28	0.30	0.21	0.34	0.27	0.25
Skewness	-0.15	-0.45	-0.11	0.07	-0.42	-0.30	-0.36	-0.21	-0.26	-0.06	-0.60	-0.20	-0.54	-0.44	-0.16	-0.36	-0.28	-0.41
Kurtosis	1.28	0.92	1.34	3.23	0.92	1.91	2.29	4.48	1.26	0.65	1.26	2.20	1.38	1.46	1.46	1.23	1.12	1.03
Inman:																		
Median	2.65	2.70	2.54	2.72	2.21	2.76	2.79	2.78	2.78	2.77	2.78	2.80	2.50	2.64	2.82	2.61	2.70	2.65
Mean	2.63	2.65	2.53	2.69	1.98	2.69	2.69	2.73	2.74	2.80	2.66	2.75	2.35	2.58	2.78	2.55	2.66	2.61
Sorting	0.22	0.25	0.26	0.17	0.58	0.19	0.20	0.15	0.21	0.14	0.12	0.18	0.22	0.28	0.18	0.32	0.25	0.27
Skewness 1	-0.06	-0.19	-0.07	-0.19	-0.40	-0.38	-0.48	-0.34	-0.17	0.21	-0.98	-0.29	-0.66	-0.20	-0.25	-0.19	-0.15	-0.16
Skewness 2	-0.45	-1.02	-0.28	1.18	-0.72	-0.50	-0.57	-0.20	-0.65	-0.53	-0.70	-0.26	-1.11	-1.29	-0.16	-0.97	-0.77	-0.96
Kurtosis	0.89	0.42	0.86	2.55	0.69	1.40	1.37	1.75	0.88	0.60	2.22	1.31	1.62	0.91	1.13	0.85	0.87	0.46
Trask (mm):																		
Median	0.16	0.15	0.17	0.15	0.22	0.15	0.14	0.15	0.15	0.15	0.15	0.14	0.18	0.16	0.14	0.16	0.15	0.16
Mean	0.16	0.16	0.17	0.16	0.24	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.18	0.16	0.14	0.17	0.16	0.16
Sorting	1.10	1.11	1.11	1.05	1.35	1.07	1.06	1.03	1.09	1.10	1.09	1.06	1.13	1.11	1.08	1.15	1.13	1.11
Skewness	1.02	1.03	1.00	1.08	1.17	1.12	1.12	1.08	1.00	1.02	1.01	1.07	1.04	1.03	1.01	1.04	1.03	1.03
Kurtosis	0.21	0.22	0.21	0.16	0.26	0.17	0.14	0.08	0.27	0.34	0.27	0.15	0.21	0.16	0.30	0.21	0.28	0.21

Table 27. Results of grain size analysis reported as weight percent at 1/4 phi intervals (with associated settling velocity) for beach samples collected during the May 7, 2001, surface map.

phi class	Settling Velocity (cm/s)	515	516	517	518	519	520	521	522	523
-1.00	2.653E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.75	2.307E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.50	1.992E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-0.25	1.708E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.453E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	1.225E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.50	1.024E+01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75	8.474E+00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.50
1.00	6.937E+00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.50
1.25	5.612E+00	0.00	0.00	3.48	0.50	2.00	0.00	0.00	0.00	1.50
1.50	4.485E+00	1.50	2.50	5.47	2.50	3.00	0.00	0.50	1.00	4.50
1.75	3.537E+00	7.50	12.00	15.42	11.00	8.50	0.00	2.50	5.99	25.50
2.00	2.751E+00	21.00	34.50	33.83	26.00	18.49	0.50	12.00	24.95	44.50
2.25	2.111E+00	43.00	40.00	26.86	35.00	31.49	5.50	28.00	40.42	18.00
2.50	1.598E+00	25.50	10.00	4.97	21.00	27.49	39.00	37.50	21.46	4.50
2.75	1.194E+00	1.50	1.00	6.47	4.00	9.00	46.00	17.50	5.99	0.50
3.00	8.821E-01	0.00	0.00	0.00	0.00	0.00	9.00	2.00	0.00	0.00
3.25	6.452E-01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.50	4.681E-01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.75	3.373E-01	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
4.00	2.419E-01	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
4.25	1.728E-01	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
14.00	2.390E-07			0.51		0.03			0.21	

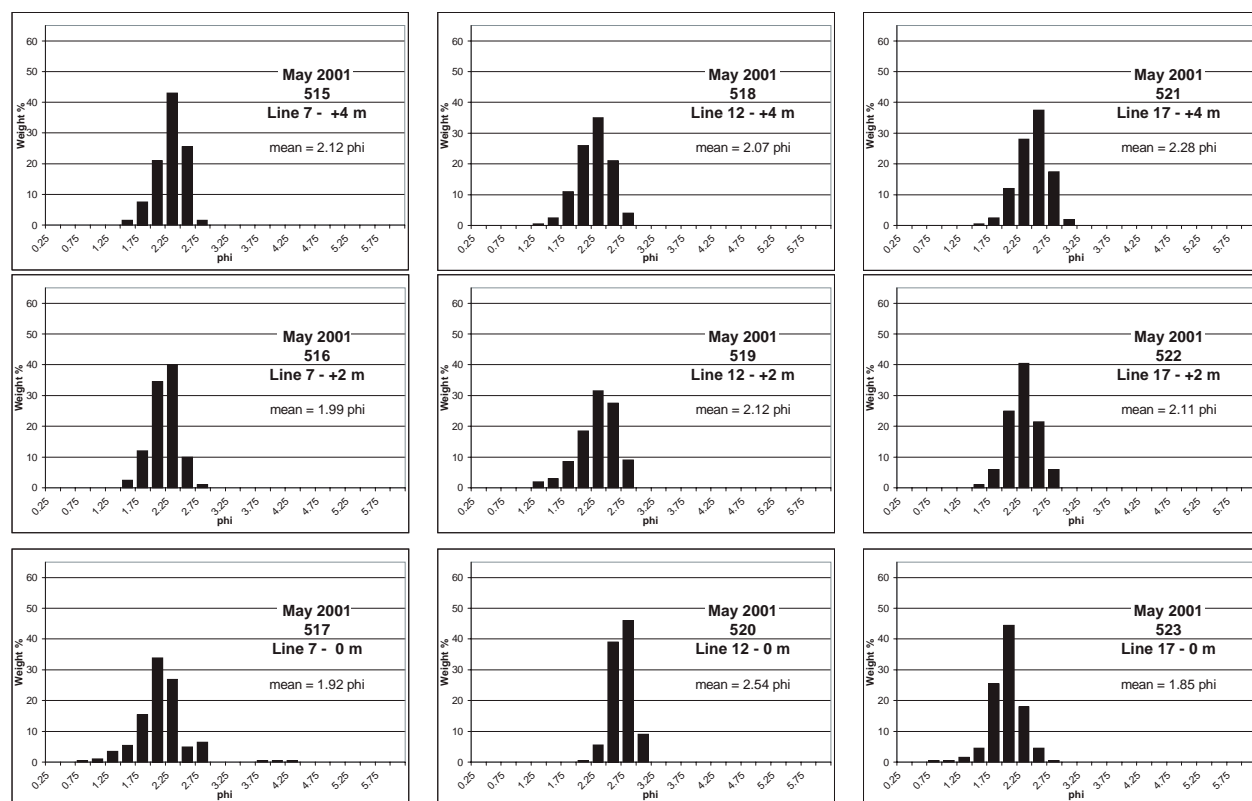


Figure 23. Histograms showing the grain size distribution of the beach sediment samples collected on May 7, 2001, during the collection of the surface map.

Table 28. Results of grain-size statistical analysis (in phi unless otherwise noted) for beach samples collected during the May 7, 2001, surface map.

Site	515	516	517	518	519	520	521	522	523
% Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Sand	100.00	100.00	98.99	100.00	99.97	100.00	100.00	99.79	100.00
% Silt	0.00	0.00	0.70	0.00	0.01	0.00	0.00	0.08	0.00
% Clay	0.00	0.00	0.32	0.00	0.02	0.00	0.00	0.13	0.00
% Mud	0.00	0.00	1.01	0.00	0.03	0.00	0.00	0.21	0.00
Moment measures:									
1st moment	2.10	1.99	1.97	2.05	2.11	2.52	2.27	2.12	1.84
Variance	0.06	0.06	0.45	0.08	0.12	0.04	0.07	0.17	0.07
Std. deviation	0.24	0.24	0.67	0.28	0.35	0.19	0.27	0.41	0.27
3rd moment	-0.54	-0.22	6.50	-0.32	1.92	-0.19	-0.36	10.44	-0.61
4th moment	3.13	3.08	68.70	2.98	52.27	3.10	3.08	181.13	5.44
Folk and Ward:									
Median	2.12	2.01	1.95	2.07	2.15	2.53	2.29	2.11	1.83
Mean	2.12	1.99	1.92	2.07	2.12	2.54	2.28	2.11	1.85
Sorting	0.23	0.22	0.35	0.28	0.32	0.15	0.24	0.23	0.20
Skewness	-0.06	-0.06	-0.07	-0.03	-0.18	0.12	-0.10	0.03	0.12
Kurtosis	1.03	1.38	2.02	0.98	1.22	1.37	0.89	1.43	1.07
Inman:									
Median	2.12	2.01	1.95	2.07	2.15	2.53	2.29	2.11	1.83
Mean	2.12	1.98	1.91	2.07	2.10	2.55	2.28	2.12	1.86
Sorting	0.24	0.21	0.28	0.29	0.30	0.11	0.27	0.20	0.16
Skewness 1	-0.03	-0.14	-0.13	0.01	-0.19	0.22	-0.01	0.06	0.20
Skewness 2	-0.12	0.02	-0.01	-0.11	-0.33	0.05	-0.26	0.01	0.08
Kurtosis	0.53	0.86	1.51	0.50	0.85	2.05	0.36	1.21	1.58
Trask (mm):									
Median	0.23	0.25	0.26	0.24	0.22	0.17	0.21	0.23	0.28
Mean	0.23	0.25	0.27	0.24	0.23	0.18	0.21	0.23	0.28
Sorting	1.11	1.08	1.10	1.13	1.14	1.07	1.12	1.09	1.11
Skewness	1.00	1.04	1.09	1.00	1.05	1.08	1.00	0.97	1.00
Kurtosis	0.22	0.18	0.15	0.30	0.23	0.26	0.27	0.21	0.29

3.2 CTD Profiles

Depth, salinity, and density were calculated from pressure, conductivity, and temperature using software provided by Sea-Bird Instruments, Inc. (Sea-Bird Electronics, Inc., 2000a). Converted data were subsampled to include only readings from the upward half of the cast and only those data acquired when pressure indicated upward movement of the instrument. In addition, only data with conductivity greater than 3.0 Siemen/m (30 mmho/cm) were included, which eliminated some readings very close to the sea surface that may have been affected by bubbles. The resulting data were interpolated using a nearest-neighbor routine to provide profiles with data at 0.2-m depth intervals (figs. 24, 25 and 26).

Two processes contributed to stratification during this experiment—upwelling and tides. Upwelling is caused by steady winds from the north and produces colder saltier conditions near the bed. Ebbing tides stratify the water column as fresher warmer water flows from Grays Harbor, and flooding tides act to destratify the water column.

The CTD profiles collected at the time of the first deployment, May 4, 2001 (fig. 24), reflect conditions after a period of strong winds. The profiles were collected over 6 hours ranging from flooding through ebbing tide. The profiles are relatively well mixed, with slight stratification resulting from warmer fresher water at the surface at Site SD, possibly due to the ebbing tide. Temperatures generally ranged between 9 and 11°C and salinities ranged from 29.5 to 31.0 psu near the surface to 31.0 to 32.5 psu at depth.

The profiles collected at the beginning of Deployment 2, on June 7 and 8, 2001 (fig. 25), were collected over a period of approximately 6 hours ranging from flood-slack to ebb-slack tide. Wind speeds were relatively low in the 3 days preceding these casts. The mild conditions allowed the development of significant stratification within the water column. Temperatures generally ranged from 13.5 to 14.5°C at the surface and 8 to 14°C near the bottom, with progressively warmer bottom water temperatures in shallower water. Salinities at the surface ranged from 29.5 to 30.0 psu and bottom waters ranged from 30.5 to 33.5 psu with progressively fresher and less dense water at shallower sites. The difference between the profiles at Site MIA and Site MIB, which are essentially the same location, illustrates the influence of tidal phase on the density profiles; the tide was ebbing during the 4 hours between casts.

The profiles collected at the end of the second deployment, on July 11, 2001, (fig. 26), were collected over a 5 hour period while the tide was flooding. There is no wind data for the period preceding these casts. There is a clear signal in the data that suggests upwelling conditions; the bottom waters are colder and saltier than in the previous two sets of profiles. Temperatures at the surface were approximately 11°C, where as near the bottom the temperature of the water ranged from 9.0 to 10.5°C. The salinity of the water ranged from 29.5 to 31.0 psu at the surface and 31.5 to 32.5 psu at the bottom. The water column shows gradual stratification of the upper 15 to 18 m except at Site MI where the upper 5 m are gradually stratified and the lower 3 m are well mixed.

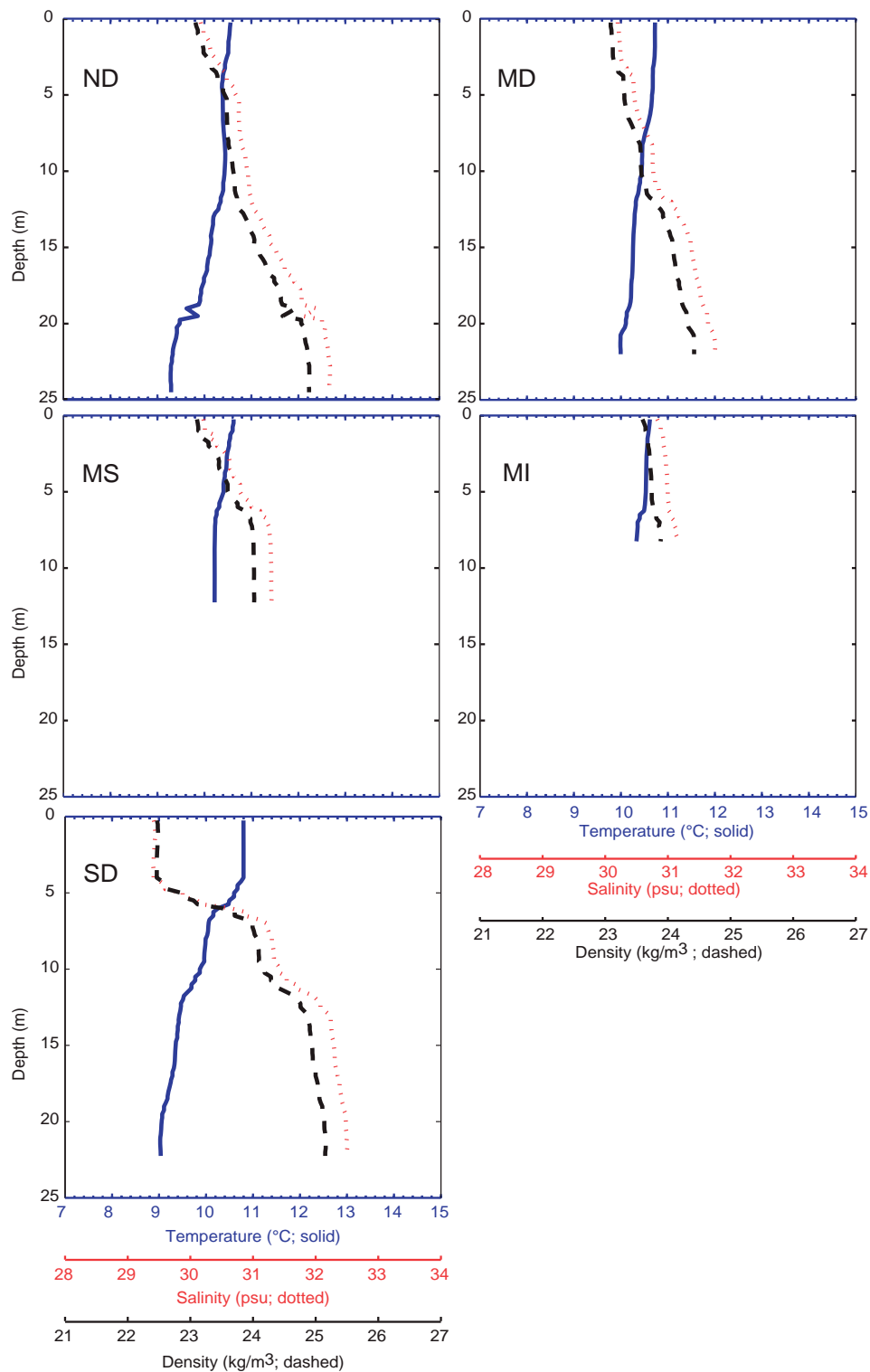


Figure 24. Profiles of salinity (dotted red line), temperature (solid blue line), and density (dashed black line) measured at Sites ND, MD, MS, MI, and SD on May 4, 2001.

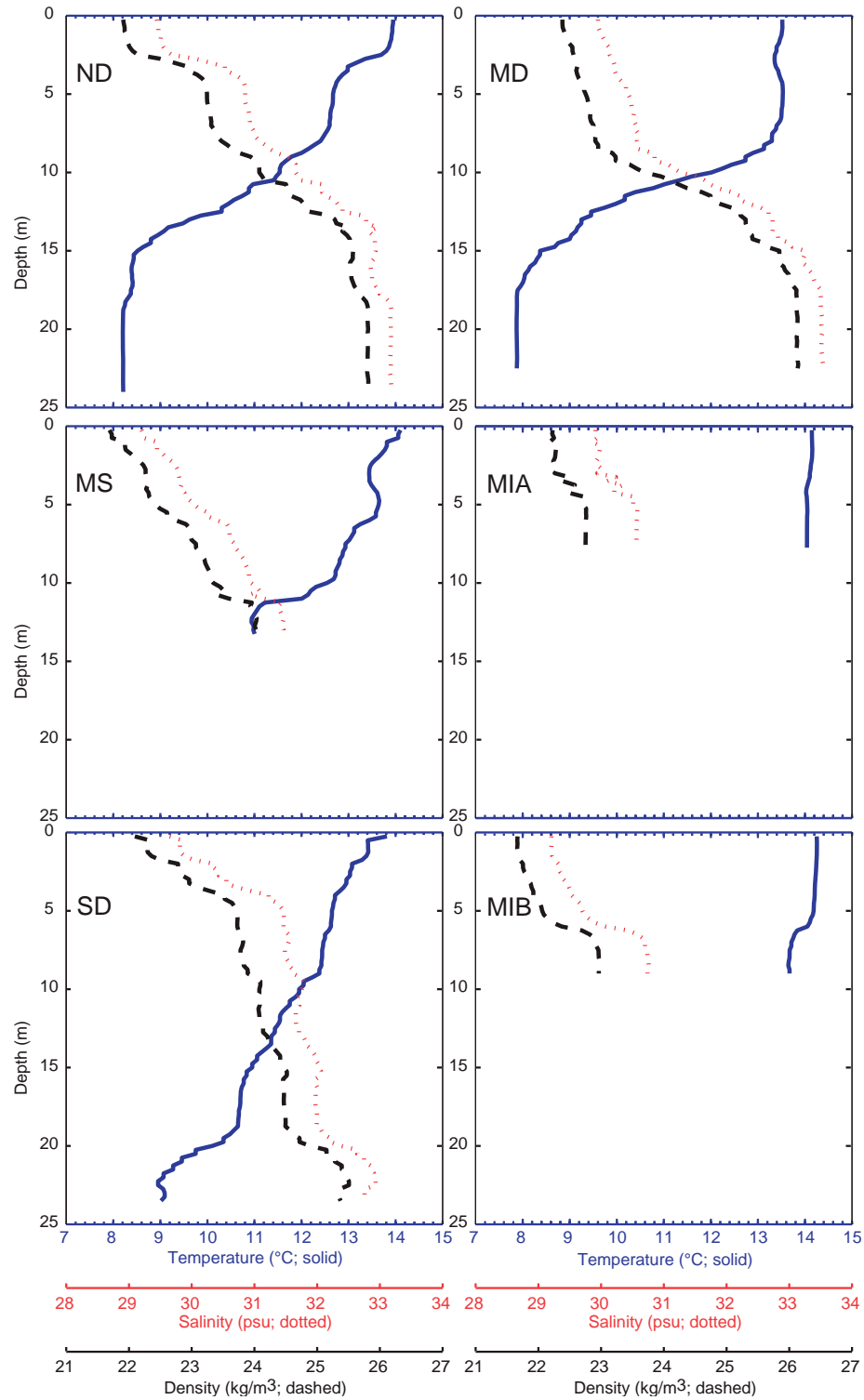


Figure 25. Profiles of salinity (dotted red line), temperature (solid blue line), and density (dashed black line) measured at Sites MS, MIB, and SD on June 7, 2001, and Sites ND, MD and MIA on June 8, 2001.

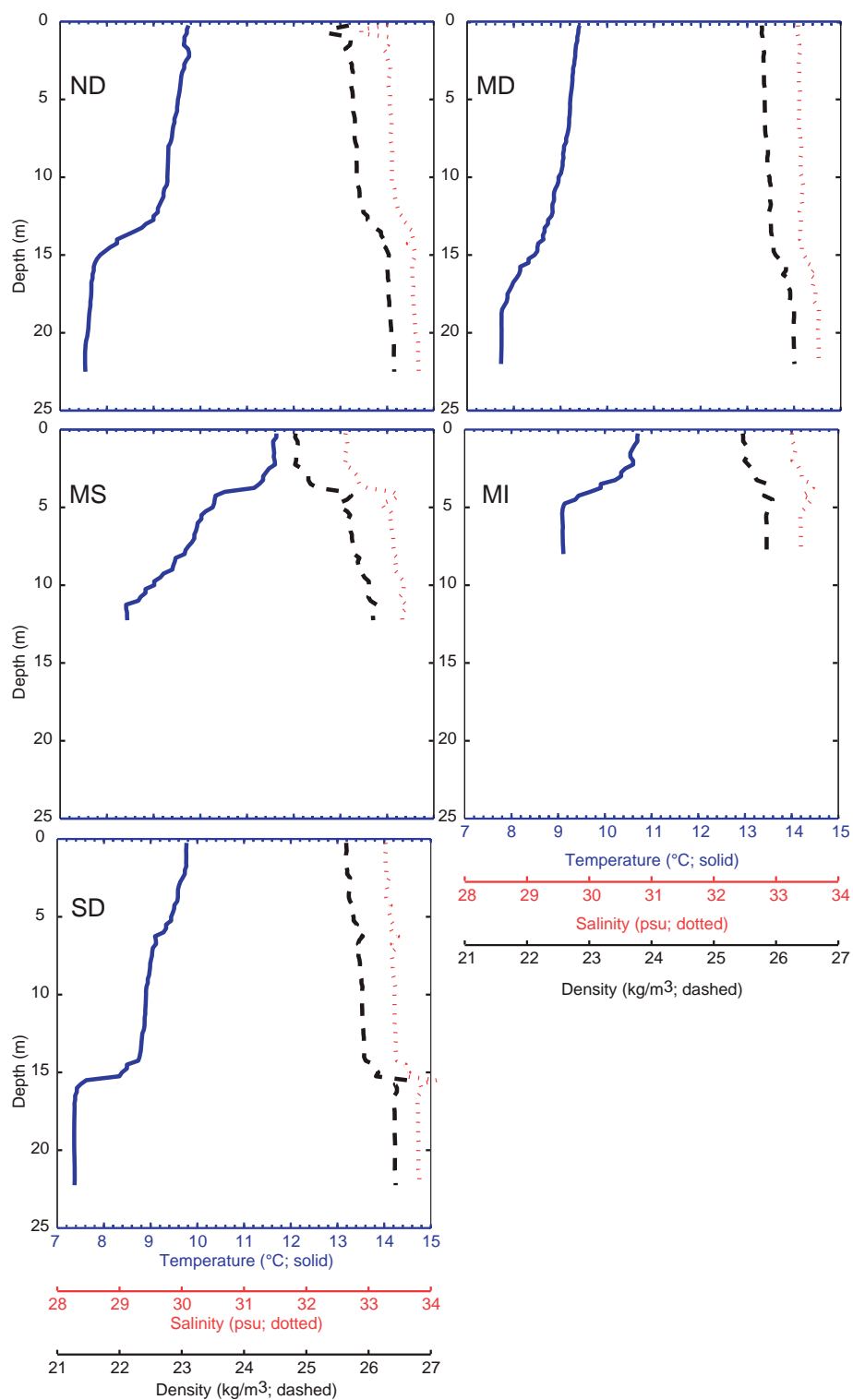


Figure 26. Profiles of salinity (dotted red line), temperature (solid blue line), and density (dashed black line) measured at Sites ND, MD, MS, MI, and MS on July 11, 2001.

3.3 Coastal Processes Measurements

High-quality data were recovered from all of the instruments deployed during the spring 2001 Grays Harbor Sediment Transport Experiment. Several observations should be noted with any interpretation of the raw data presented in this report:

- (1) The measured distance between the instruments and the sea floor changed (and generally decreased) at all six tripod sites during each deployment (as measured by the SonTek acoustic Doppler ocean velocimeters, ADVs, and the pulse-coherent acoustic Doppler profiler, PCADP), suggesting that the tripods either were being worked into the bed (likely) or that net deposition of sediment occurred (not as likely). Estimates of sensor elevation are particularly important for interpretation of current and suspended sediment data from the velocimeters, profilers, and optical and acoustic backscatter sensors. Although the ADVF is also equipped to measure distance to the bottom, these instruments, deployed at Site MIA, were deployed too far from the bottom to detect the bottom during this experiment.
- (2) The compass in the ADVO at Site ND was damaged either before the first deployment or shortly after being deployed and remained broken throughout the experiment. In addition to bad heading, pitch, and roll, velocity measurements, particularly vertical velocities, should be treated with suspicion. The orientation of the tripod was determined using the compass data collected by the ADP also deployed on the tripod at Site ND.
- (3) A firmware error resulted in the collection of bad pressure data by the two SonTek acoustic Doppler field velocimeters (ADVFs) deployed at Site MIA.
- (4) Interference at radio frequencies distorted the instantaneous burst measurements made by the OBS and logged on the Hydra systems. The burst-mean values are unaffected by this problem, which is discussed in more detail in appendix F.

Periods of valid data collection (that is times when the tripod was on the bottom during the entire burst) are shown in table 29. The start and end times of valid data collection for the ADVs, PCADP, and ADPs were determined through visual investigation of the within burst pressure and correlation records and the heading data. Sonar data processing and example results are described in section 3.3.7.

Preliminary analysis of the data collected during the experiment identified some erroneous data points. The bad data points from the ADP and ADV and PCADP Hydra system data records are listed in table 30. In general, only problems with burst means have been identified. Individual bad data points within bursts have not been documented in the table, though some problems with entire burst time series have been identified. The specific problems encountered with the instrumentation are detailed for each tripod in section 2.4.2. Specific problems worth noting are:

- (1) At times the water depth was too great for the ADP pressure sensor at Site SD, resulting in bad pressure data. The criteria for deciding whether a pressure point was bad included (1) residual greater than 1.5 standard deviations from the burst-mean or (2) changes greater than 0.5 dbar.
- (2) Some PCADP data from Deployment 2 had poor correlation statistics.
- (3) Significant biofouling of many of the OBS sensors occurred towards the end of both deployments and can easily be seen in the affected OBS data records. On the basis of visual inspection of the data records, data points determined to be bad due to biofouling are reported in table 31.

Figures 28 through 97 show data collected by the ABS, ADPs, and ADV and PCADP Hydra systems during the two deployments. Data are grouped by the site where they were collected. The time at which each time series point is plotted has been adjusted to represent the center of the burst. Therefore, if a burst started 10 minutes before the hour, and the burst lasted 20 minutes, then 10 minutes were added to the start time and the burst was plotted on the hour. All heights listed as meters or centimeters above the bed (mab and cmab respectively) are nominal.

Data collected while the tripod was not on the bottom for the entire burst were not plotted. Bad mean pressure data flagged in table 30 have not been plotted. Other flagged data points were not necessarily removed before plotting, though the axes may have been adjusted in such a way that data outliers are not included in the plots.

The PCADP along-beam velocities were corrected for ambiguity errors using the resolution velocities measured by the PCADP (described in section 2.4.1.3) and the algorithm described in Lacy and Sherwood (in press; fig. 27). Along-beam velocities were converted to east, north, and vertical velocities using heading, pitch, and roll measured by the instrument, and correcting for magnetic declination.

East and north velocity and heading data were corrected for magnetic north before plotting, and are therefore plotted as true north ($^{\circ}$ T). Magnetic declination in the Grays Harbor area is 19° E. Speed and direction are calculated using these corrected velocities. This correction has not been made to the data files provided on the DVDs.

For the plots in this section, positive alongshore is assumed to be true north ($^{\circ}$ T), and positive cross-shore is assumed to be due east for all sites, including SD, where the coast is actually aligned with 330° T.

Pressure data were adjusted by removing an approximate value for atmospheric pressure of 10.209 dbar for all instrumentation except the PCADP. The pressure record from the PCADP was corrected for atmospheric pressure by subtracting the barometric pressure from the meteorologic station. The data from the meteorologic station is incomplete after June 2001. Therefore, the last recorded atmospheric pressure (10.18 dbar) was used for correcting the rest of the time series. The mean barometric pressure for the two month data record is 10.16 dbar.

Distance to the bottom as defined for the ADV is the distance from the center of the ADV sampling volume to the bed; bad data points have not been flagged. Distance to the bottom as measured by the PCADP is the measured distance from each of the three transducers to the bottom; measurements less than 0.7 m were discarded as bad (table 30). Results are presented for each of the three beams.

OBS data are plotted as raw output from the Hydra system (counts) and as suspended sediment concentration in kg/m^3 . Suspended sediment concentration was calculated using calibration curves obtained through laboratory analysis. Details of the calibrations are found in appendix E.

All OBS data were influenced by biofouling towards the end of Deployment 1, except OBS 2 deployed on the ADV Hydra system at Site SD. During Deployment 2 the OBS from eve site except ND and SD were influenced by biofouling. In the following plots, all valid OBS data points are plotted; those suspected of contamination through biofouling (table 31) are plotted in grey.

The low-pass filtered velocity plots show horizontal velocity data low-pass filtered at 40 hours and then decimated to 4-hour intervals for plotting. These data were separated into east-north components and the cumulative transport in the alongshore (north-south) and cross-shore (east-west) directions were calculated by taking the cumulative sum of the product of the velocity component and Δt (4 hours).

The low-pass filtered velocity data were multiplied by the calibrated OBS 1 data (OBS 2 for Site MIB) that were also low-pass filtered and decimated to 4-hour intervals to construct the suspended sediment flux plots. OBS 1 and the cumulative transport data were used in constructing the cumulative suspended sediment transport plots. OBS 1 was deployed nearest to the sampling volume of the ADVOs and ADVFs except at Site MIB, where OBS 2 was deployed at the level of the ADVO sampling volume.

The ABS data are plotted as “ABS units” which are uncalibrated units produced by the ABS. In low concentrations, these units are proportional to sediment concentration to some power, but the response varies as a function of distance from the transducer and sediment concentration.

Table 29. Date, time, and burst number of first and last valid data record for each acoustic Doppler profiler (ADP) and acoustic Doppler (Ocean and Field) velocimeter (ADVO and ADVF respectively) and pulse-coherent acoustic Doppler profiler (PCADP) Hydra system deployed.

Site	Instrument	Deployment 1		Deployment 2	
		First Good Record - Start Time	Last Good Record - Start Time	First Good Record - Start Time	Last Good Record - Start Time
ND	ADVO	May 4 15:50:01 Burst 4	June 5 19:50:01 Burst 776	June 8 03:50:01 Burst 6	July 11 15:50:01 Burst 810
ND	ADP	May 4 15:56:35 Burst 7	June 5 19:56:35 Burst 1551	June 8 03:26:36 Burst 8	July 11 15:56:35 Burst 1617
MD	ADVO	May 4 20:50:02 Burst 3	June 5 17:50:02 Burst 768	June 8 02:50:02 Burst 4	July 11 16:50:02 Burst 810
MD	ADP	4 May 20:55:00 Burst 5	5 June 19:25:00 Burst 1538	June 8 02:55:00 Burst 7	July 11 16:55:00 Burst 1619
MS	ADVO	May 4 20:50:01 Burst 2	June 5 18:50:01 Burst 768	June 7 21:50:01 Burst 6	July 11 19:50:01 Burst 818
MIA	PCADP	May 4 14:50:04 Burst 3	June 5 14:50:04 Burst 771	June 8 02:50:04 Burst 4	July 11 19:50:01 Burst 813
	ADVF 231	May 4 14:50:00 Burst 2	June 5 14:50:00 Burst 386	N/A	N/A
	ADVF 244	May 4 14:50:00 Burst 2	June 5 14:50:00 Burst 386	June 8 04:50:00 Burst 5	July 11 19:50:00 Burst 812
MIB	ADVO	4 May 14:50:02 Burst 3	5 June 14:50:02 Burst 771	June 7 22:50:02 Burst 7	July 11 19:50:02 Burst 820
SD	ADVO	May 4 21:50:02 Burst 4	5 June 15:50:02 Burst 766	June 7 21:50:02 Burst 6	July 11 17:50:02 Burst 818
	ADP	May 4 21:56:35 Burst 7	June 5 16:26:36 Burst 1532	June 7 20:56:35 Burst 3	July 11 17:56:37 Burst 1629

Table 30. Flagged bad data points from the acoustic Doppler profilers (ADPs) and acoustic Doppler (Ocean and Field) velocimeters (ADVO and ADVF respectively) and pulse-coherent acoustic Doppler profiler (PCADP) Hydra systems.

[List does not include the points flagged as out of the water (table 29). [(OBS—optical backscatter sensor)]

Site	Instrument	Deployment	Data Type effected	Burst Numbers
ALL ND	ADVO, ADVF, and PCADP ADVO	1 and 2	OBS	ALL intra-burst values; burst-means should be ok except as noted below.
		1	Heading, Pitch, and Roll	all
		2	Heading, Pitch, and Roll	all
		1	OBS2	155, 660
MIA	ADVO	2	OBS2	657, 658, 659, 662
		1	Pressure	all
		2	Pressure	all
		1	Distance to Bottom	all
	ADVF - S/N 244	2	Distance to Bottom	all
		1	Pressure	137, 227, 281, 282, 353
		1	Distance to Bottom	all
		2	Distance to Bottom	all
	PCADP	1	Beam 1 distance to bottom	42, 293, 472, 473, 482
		1	Beam 2 distance to bottom	49, 173, 278, 319, 693
		1	Beam 3 distance to bottom	478, 500
		2	Beam 2 distance to bottom	332, 362, 430, 801
		2	Beam 3 distance to bottom	189, 341, 346, 350, 474
		2	Velocity	5-122
		1	OBS1	467,468
		2	OBS1	446, 470, 472, 474, 480, 497, 498
SD	ADVO	2	OBS2	88
		1	Pressure	120-124, 170-173, 220-221, 889-892, 939-941, 987-991, 1037-1039, 1086-1090, 1138, 1464-1465, 1511-1515
	ADP	1	Pressure	120-124, 170-173, 220-221, 889-892, 939-941, 987-991, 1037-1039, 1086-1090, 1138, 1464-1465, 1511-1515
		2	Pressure	24-29, 74-79, 124-126, 747, 796-797, 844-848, 894-897, 922-923, 946, 1019-1025, 1069-1075, 1168-1173, 1218-1224, 1268-1273, 1317-1322, 1366-1371, 1466-1468, 1515-1518

Table 31. Optical backscatter (OBS) data points influenced by biofouling.

[(ADVO—acoustic Doppler velocimeter; ADVF—acoustic Doppler Field velocimeter; PCADP—pulse-coherent acoustic Doppler profiler; S/N—serial number)]

Site	Instrument Type and S/N	Deployment	OBS No.	Burst Numbers	
ND	ADV0	1	1	495 to end	
			2	567 to end	
MD	ADV0	1	1	571 to end	
			2	587 to end	
		2	1	558 to end	
			2	612 to end	
MS	ADV0	1	1	495 to end	
			2	503 to end	
		2	1	571 to end	
			2	503 to end	
MIA	PCADP H40	1	1	552 to end	
			2	703 to end	
		2	1	508 to end	
			2	525 to end	
	ADVF S/N 244	1	1	294 to end	
			2	291 to end	
		2	1	520 to end	
			2	523 to end	
	ADVF S/N 231	1	1	292 to end	
			2	226 to end	
MIB		ADV0	1	1	568 to end
				2	400 to end
	2		1	637 to end	
			2	406 to end	
SD	ADV0	1	1	367 to end	

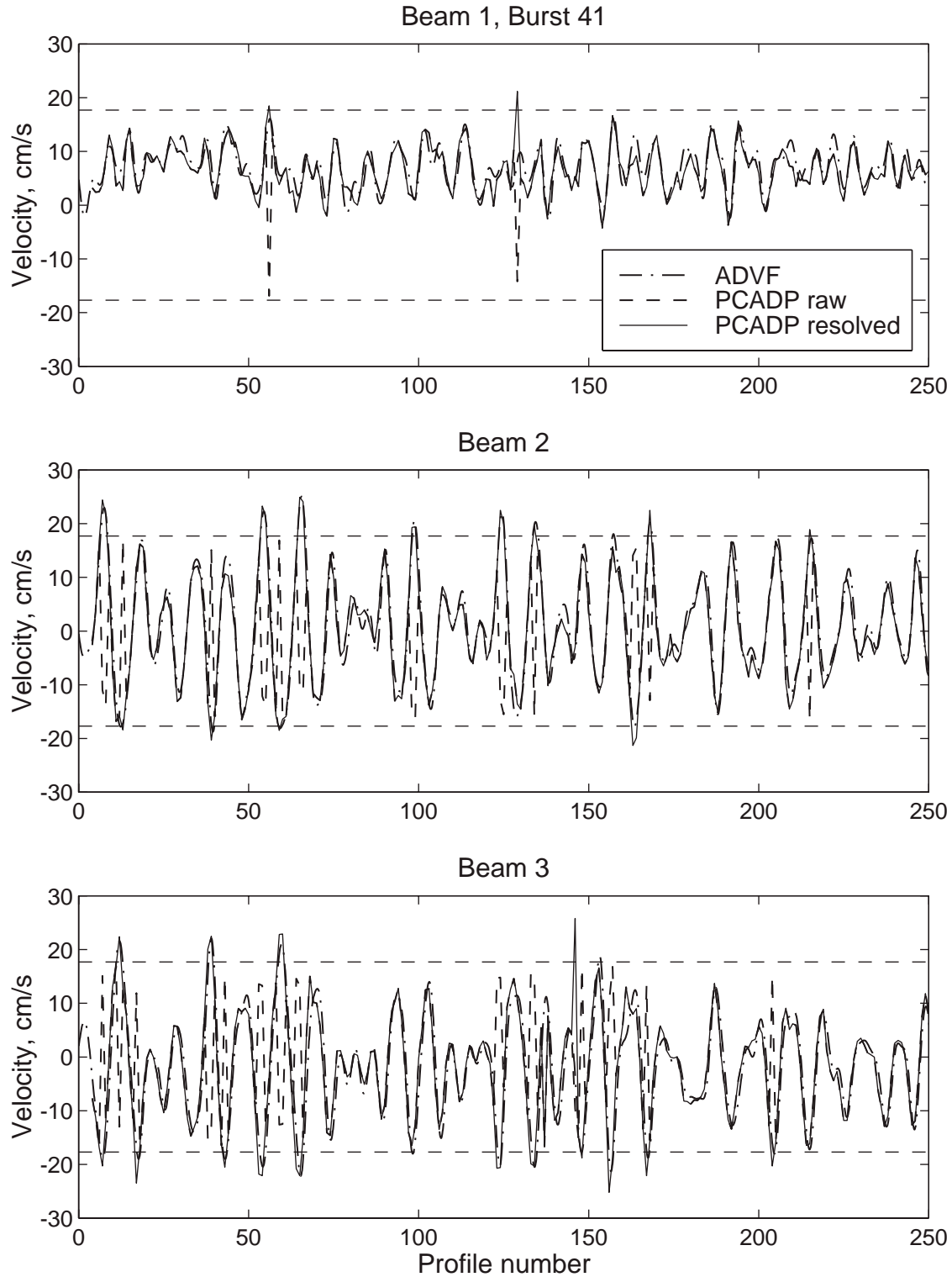


Figure 27. Time series (within burst) from acoustic Doppler Field velocimeter (ADVF) and cell 5 of pulse-coherent acoustic Doppler profiler (PCADP), before and after ambiguity resolution, in PCADP beam coordinates. Profiles were measured at 1 Hz. Dashed horizontal lines are at $\pm V_a/2$, as described in section 2.4.1.3.

3.3.1 Site ND

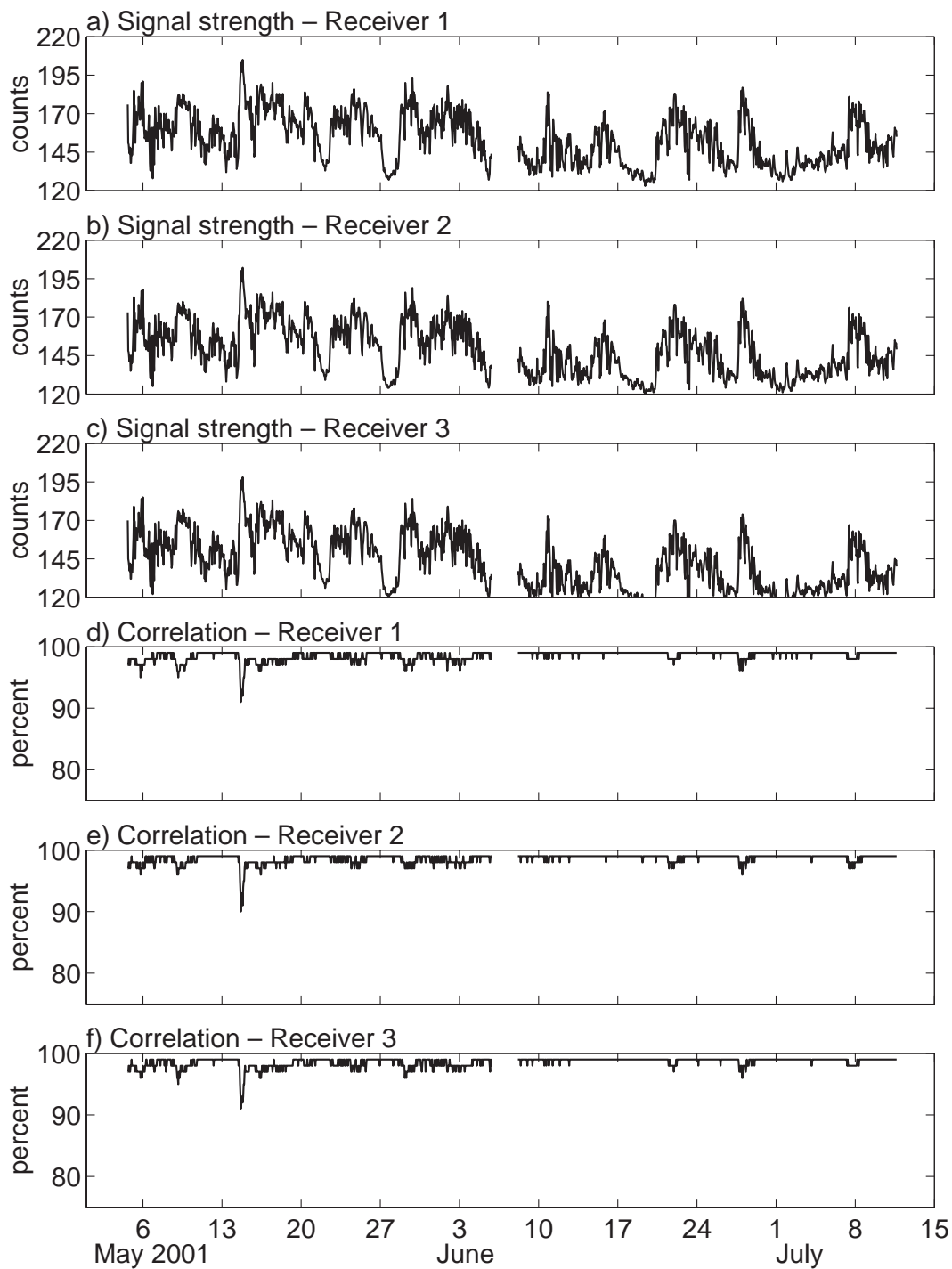


Figure 28. Time series of signal strength and signal correlation for each acoustic Doppler Ocean velocimeter (ADV0) receiver at Site ND.

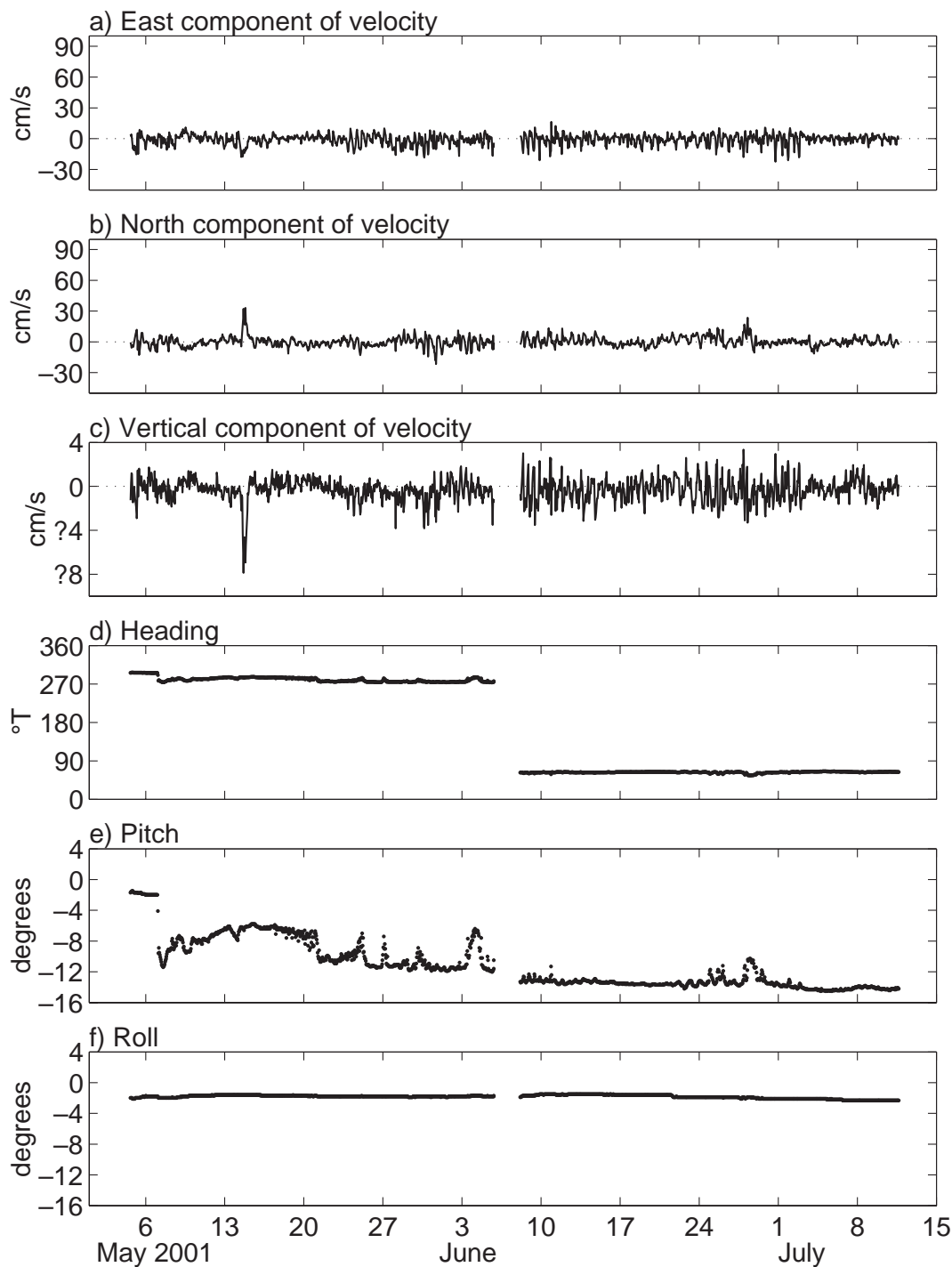


Figure 29. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site ND. The compass on the ADVO at this site was damaged before the first deployment; this is most apparent in the pitch time series. Therefore, velocities, particularly the vertical velocities, from this data record should be treated with caution. Instrument log sheets suggest that the actual heading may be within 30 degrees of that recorded by the instrument. °T—degrees from true north.

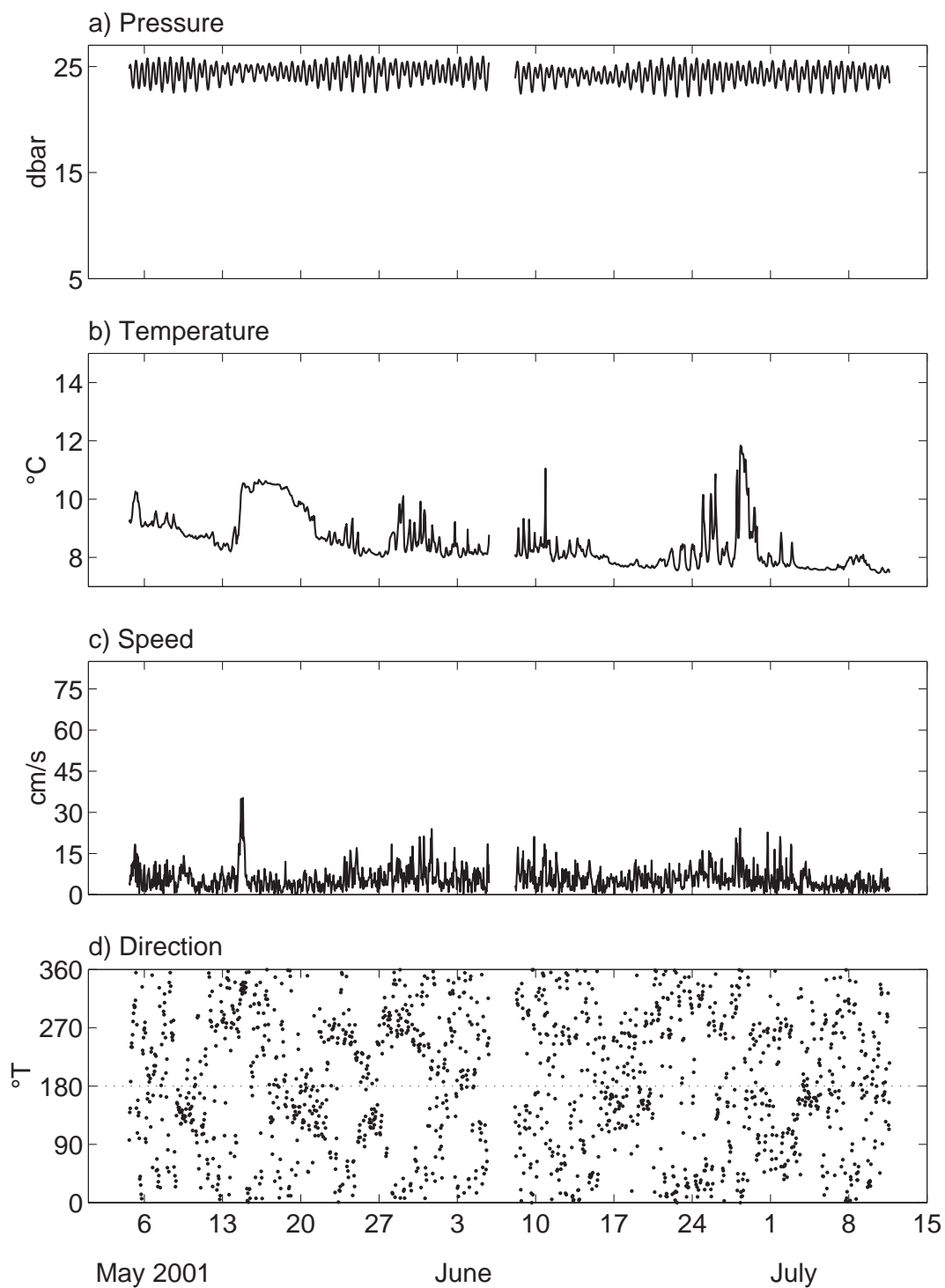


Figure 30. Time series of pressure, temperature, speed, and direction from the data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site ND. °T—degrees from true north.

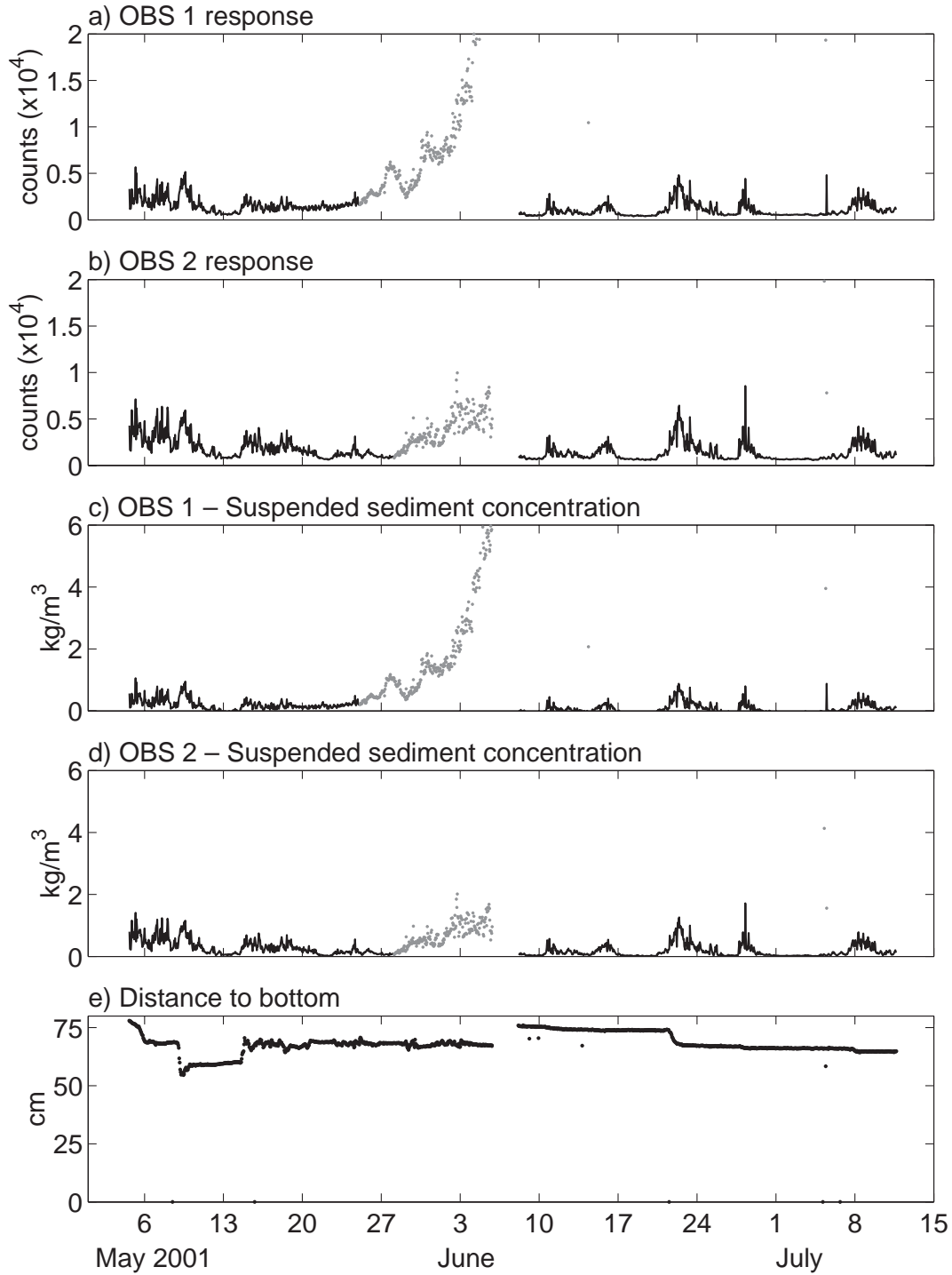


Figure 31. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site ND. The entire OBS record is displayed; data influenced by biofouling is in grey. Distance to bottom is distance from the center of the ADVO sampling volume.

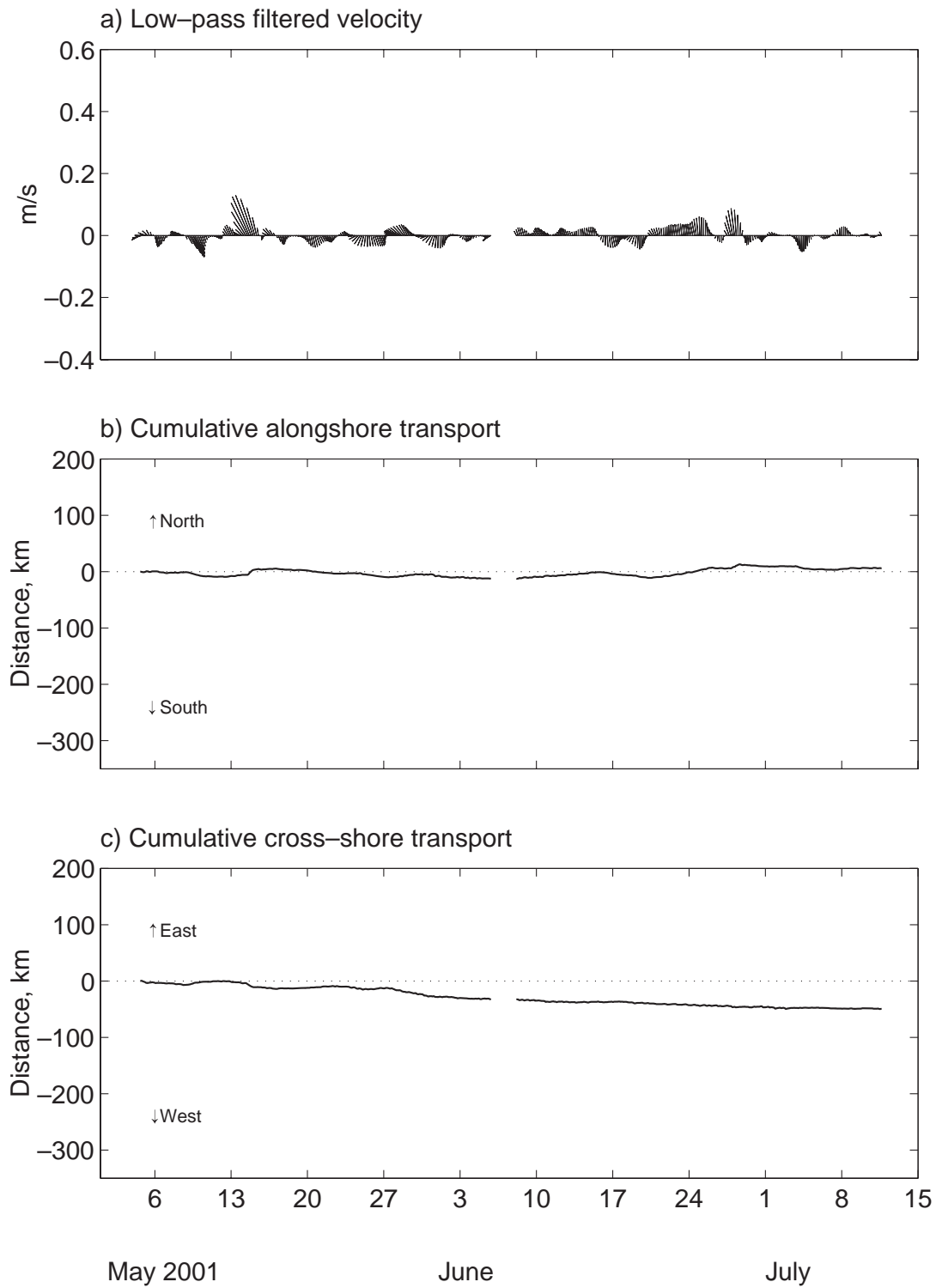


Figure 32. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site ND.

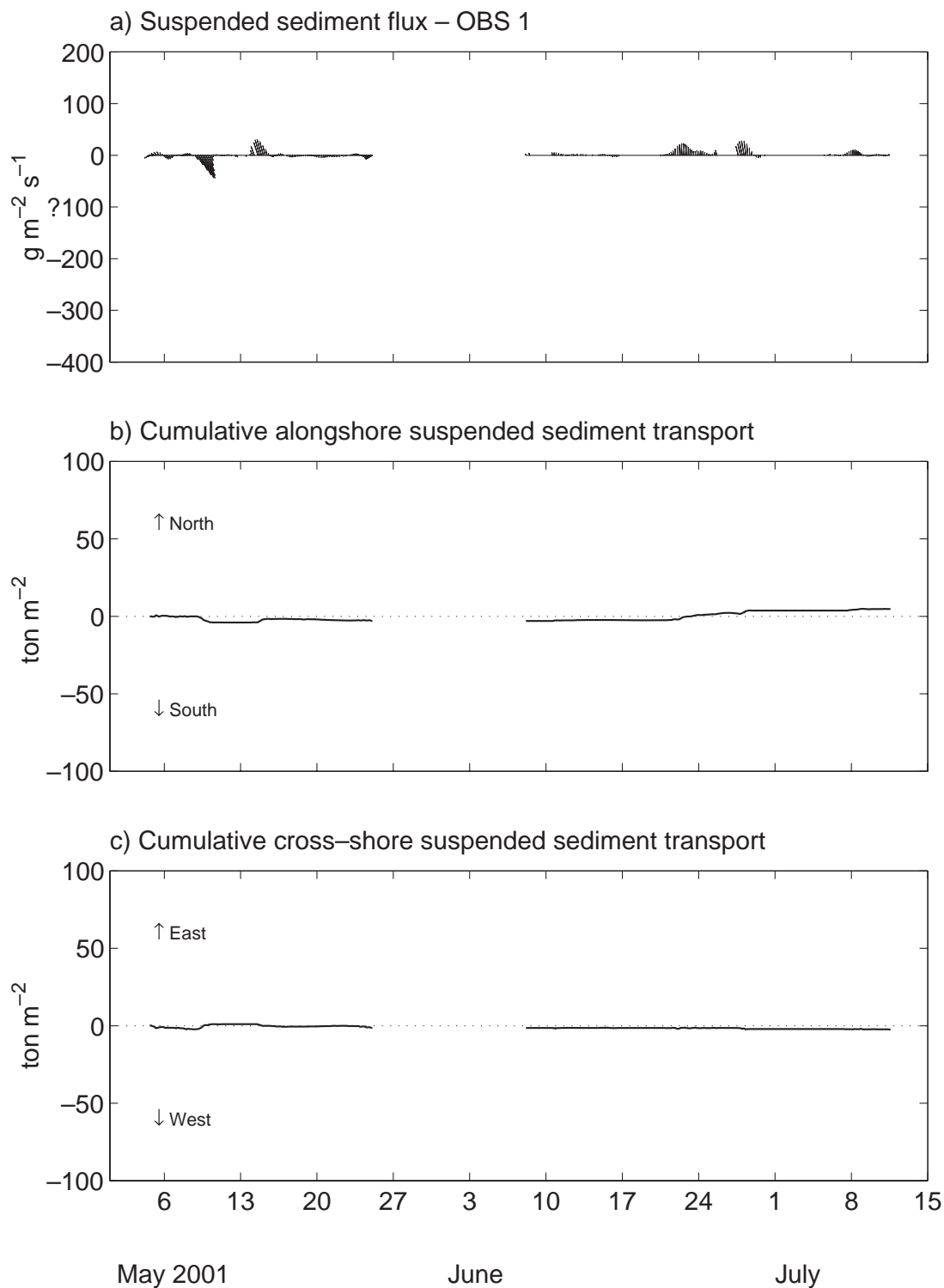


Figure 33. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site ND. Times series is constrained to period of nonbiofouled optical backscatter sensor (OBS) data collection.

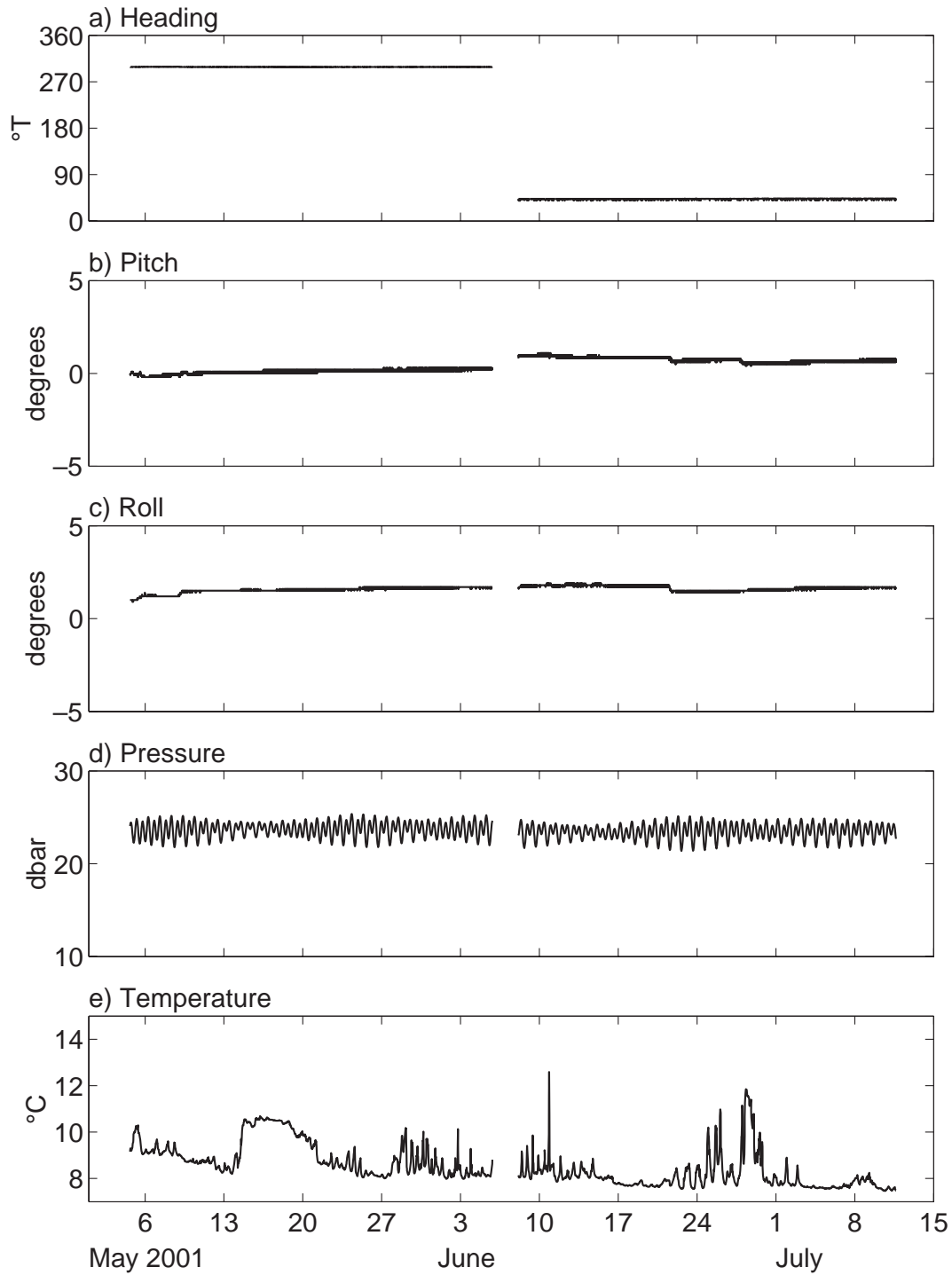


Figure 34. Time series of heading, pitch, roll, pressure, and temperature data collected by the acoustic Doppler profiler (ADP) at Site ND. $^{\circ}\text{T}$ —degrees from true north.

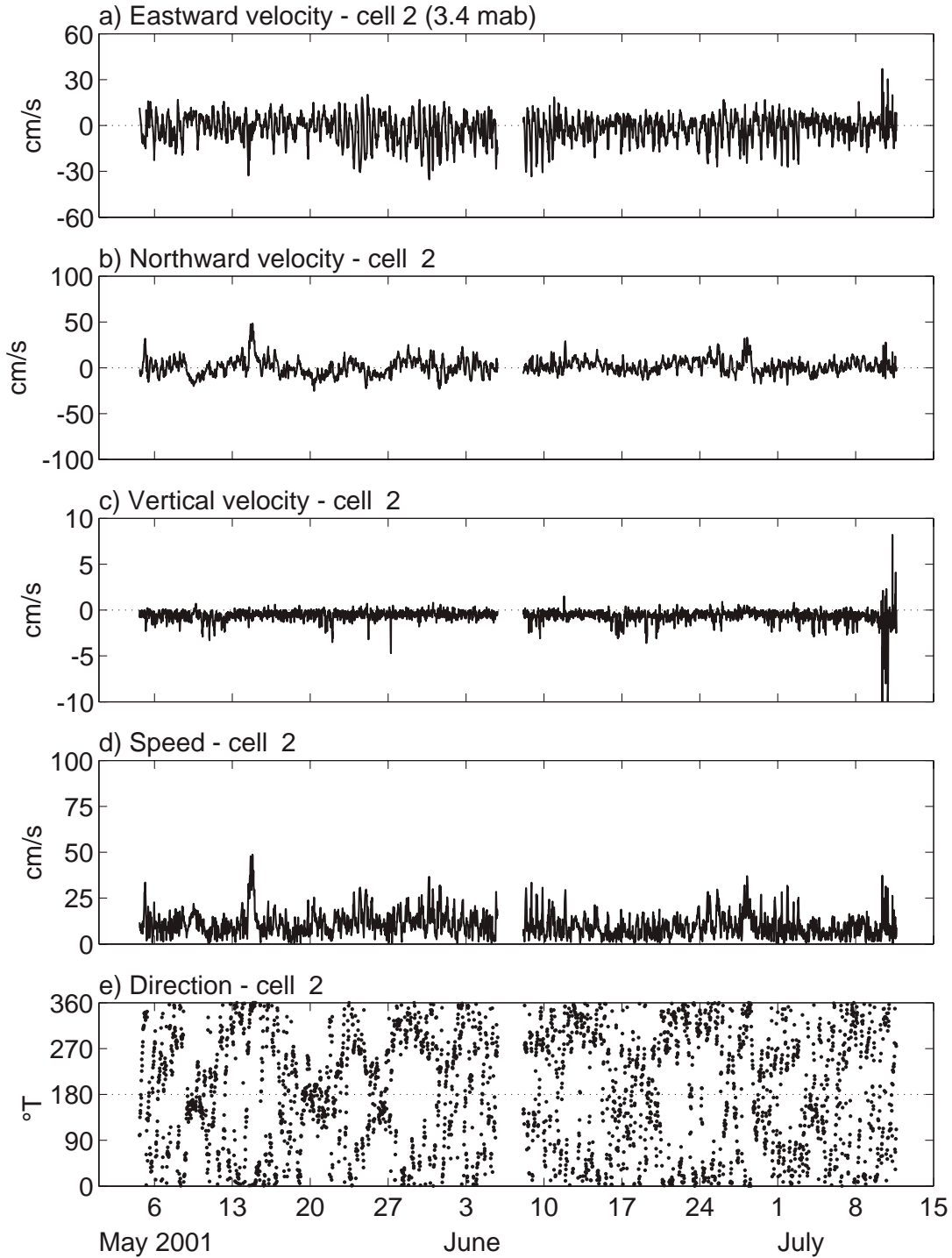


Figure 35. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 2 (3.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site ND. °T—degrees from true north.

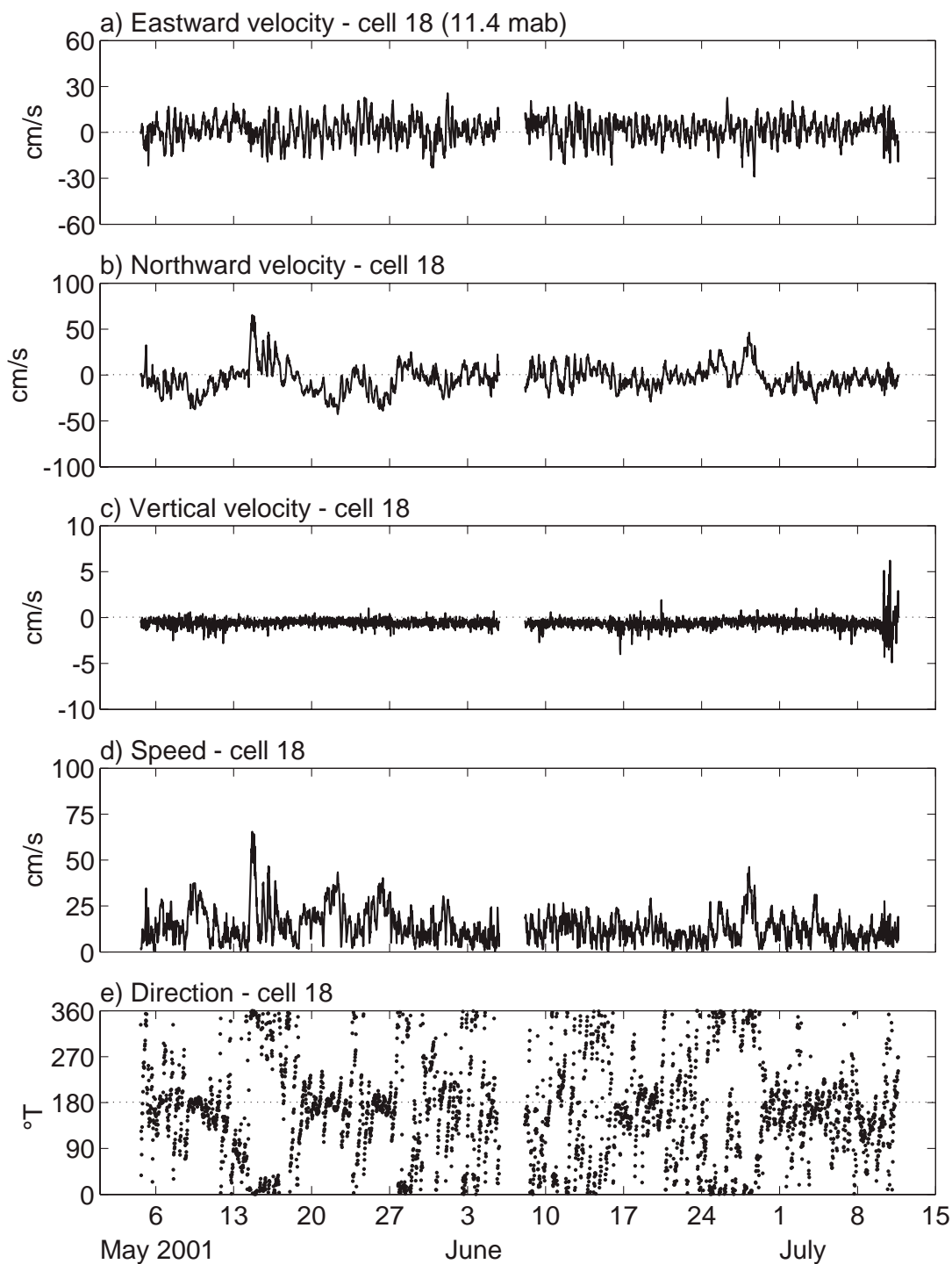


Figure 36. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 18 (11.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site ND. $^{\circ}\text{T}$ —degrees from true north.

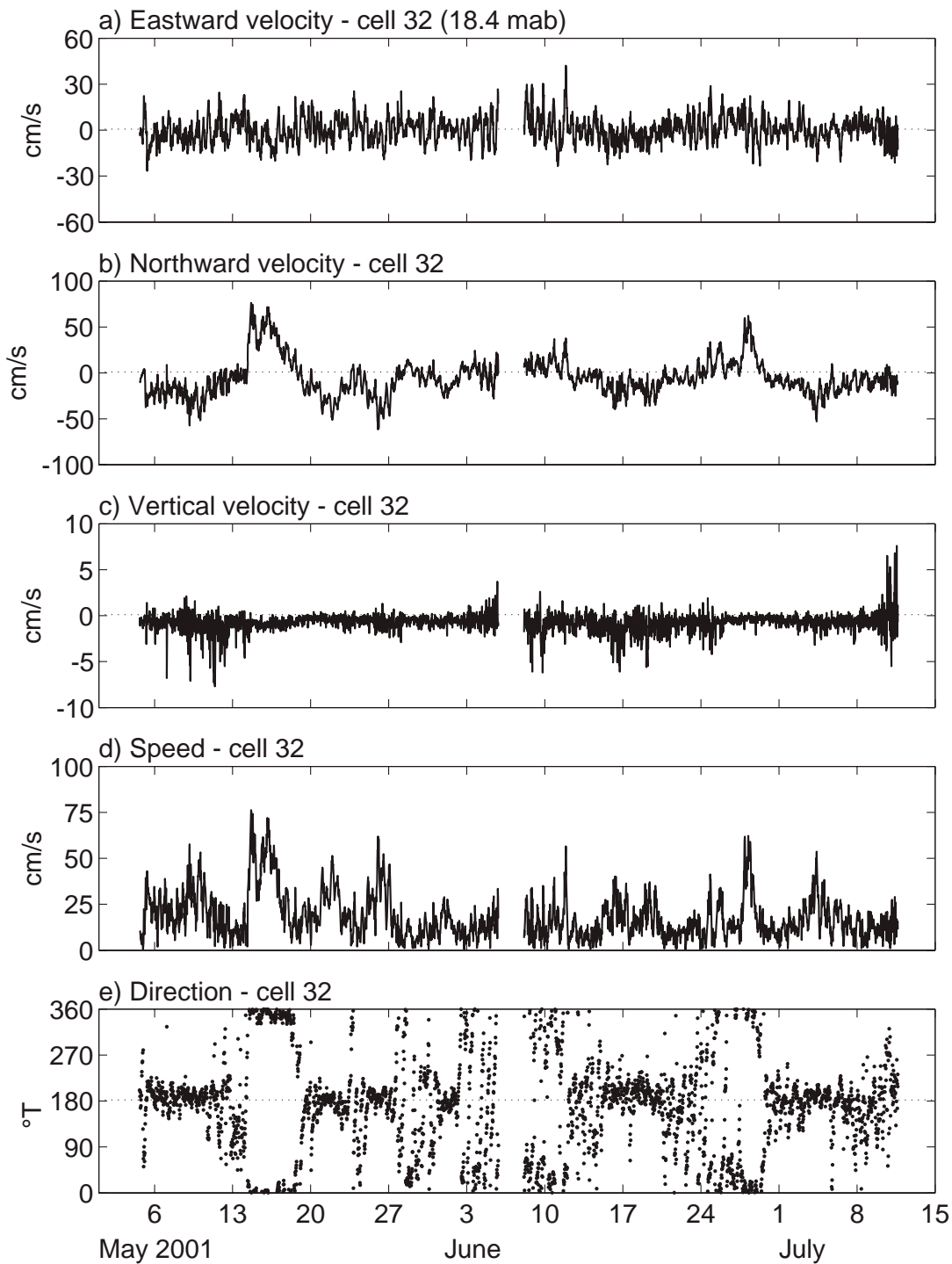


Figure 37. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 32 (18.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site ND. °T—degrees from true north.

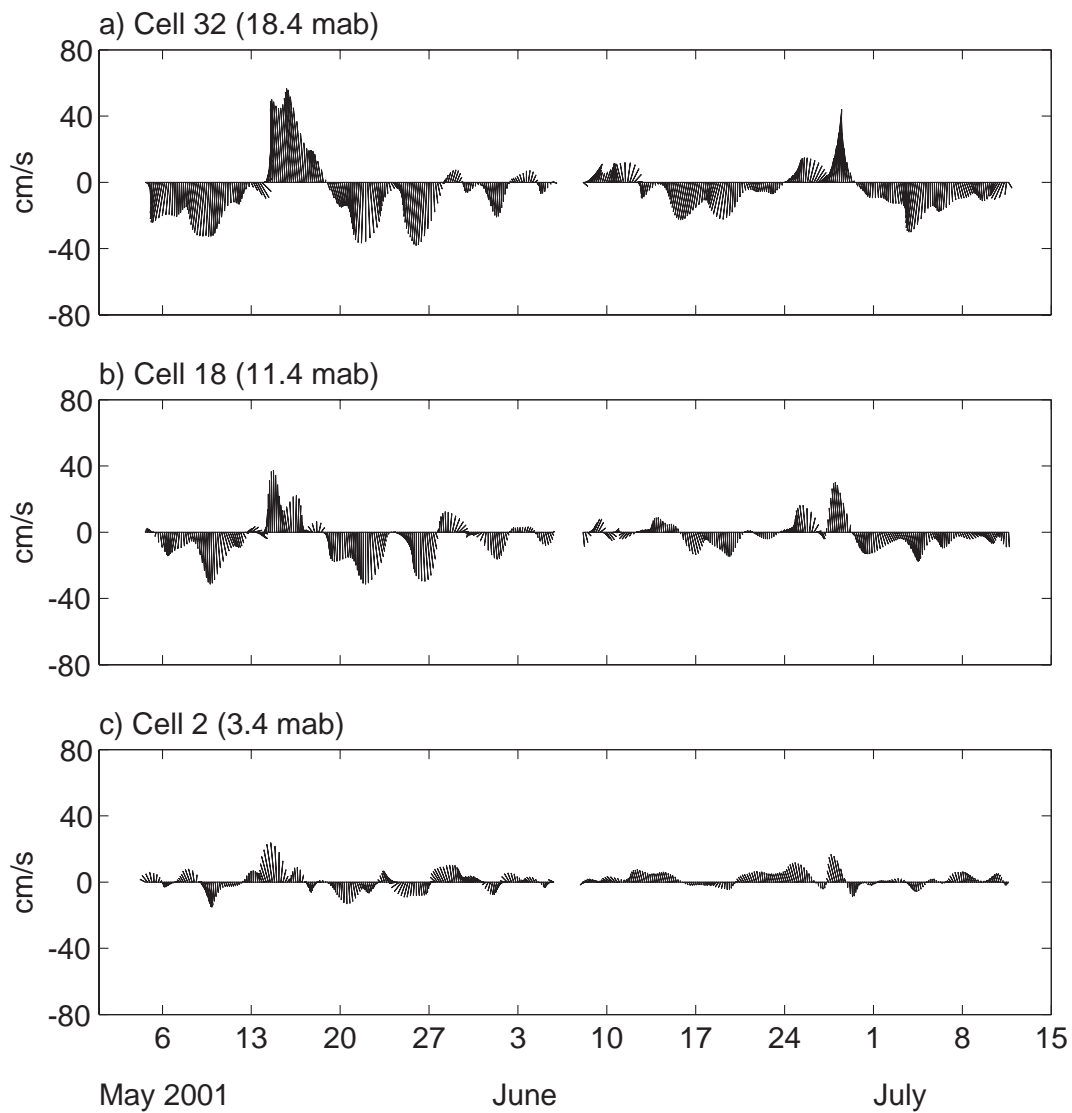


Figure 38. Time series of low-pass filtered velocity for several acoustic Doppler profiler (ADP) cells at Site ND. °T—degrees from true north; mab—meters above bed.

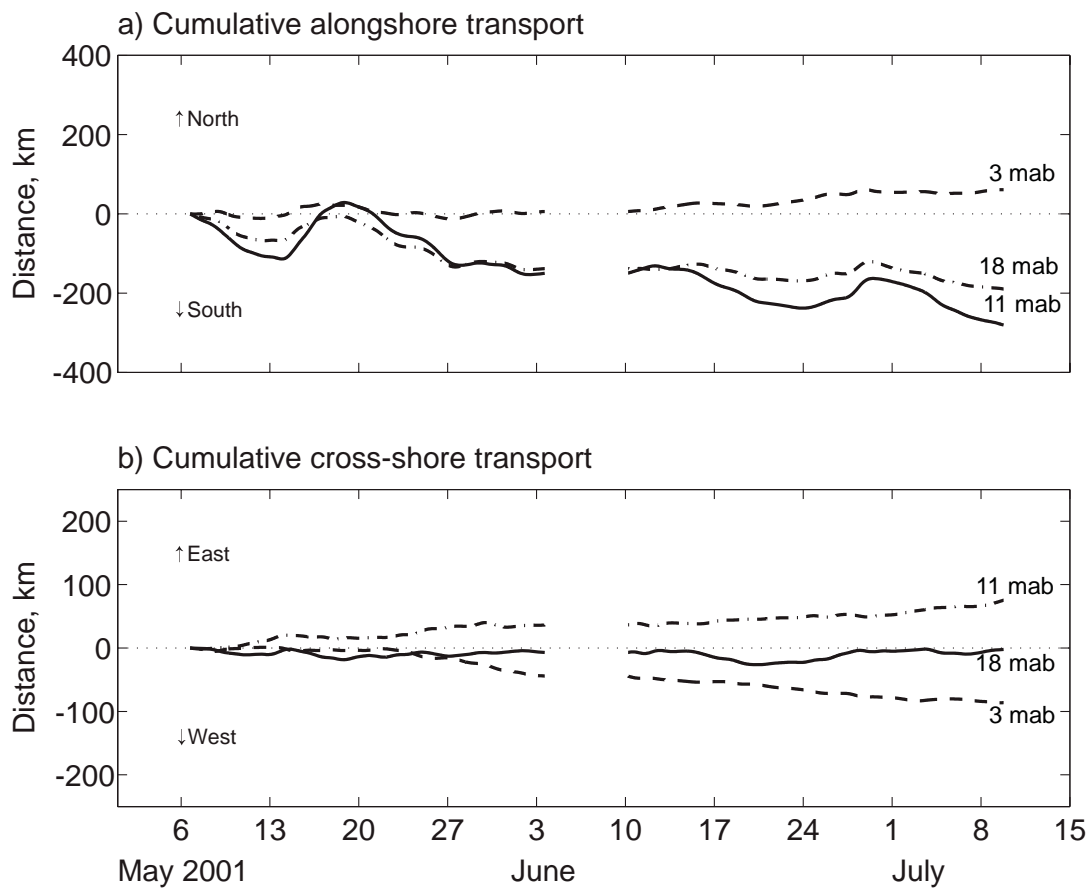


Figure 39. Time series of cumulative alongshore and cross-shore transport for several acoustic Doppler profiler (ADP) cells at Site ND. Data are presented at heights of approximately 3 (dashed line,--), 11 (dash-dotted line, -.), and 18 (solid line,-) mab (meters above bed).

3.3.2 Site MD

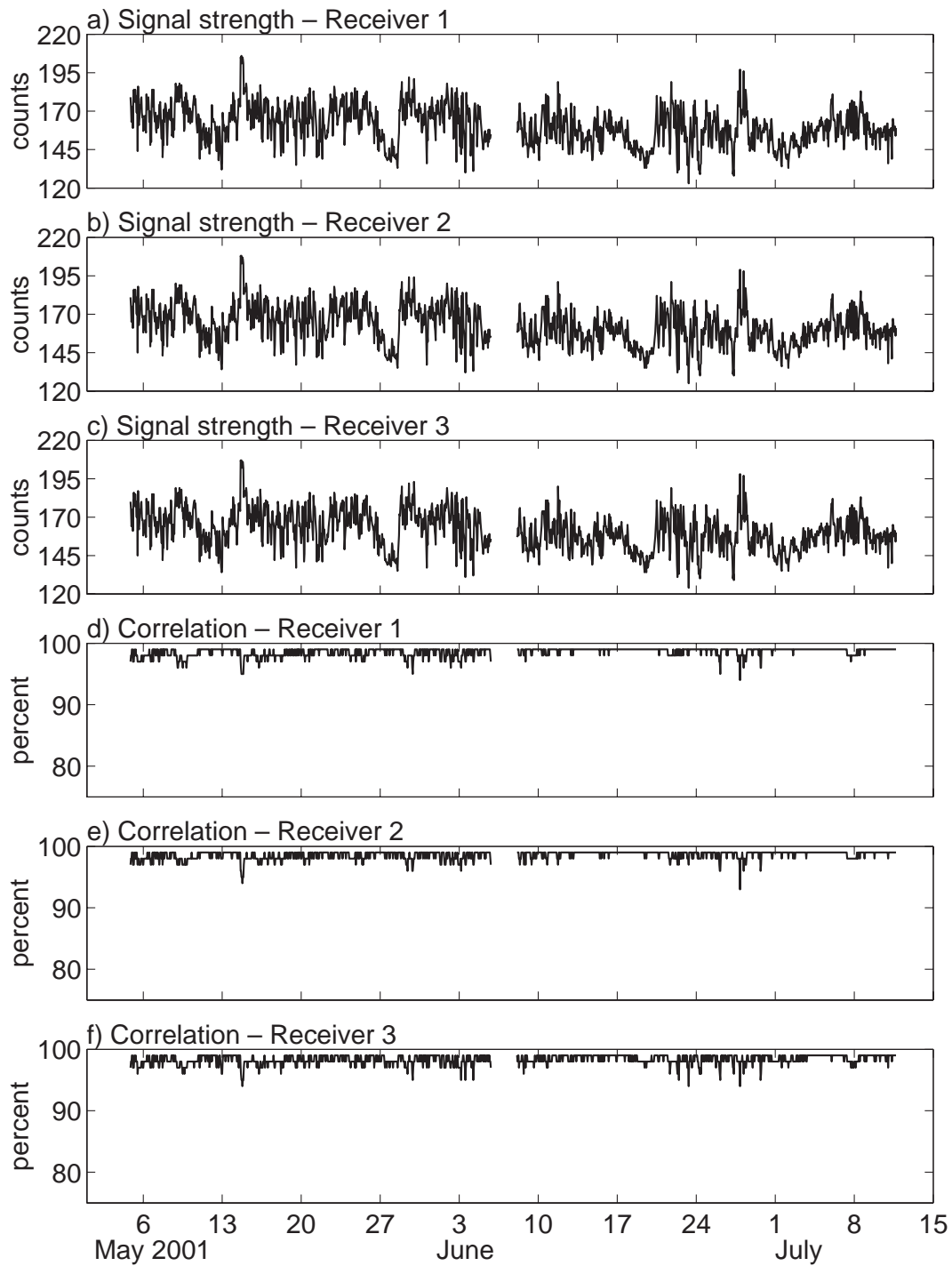


Figure 40. Time series of signal strength and signal correlation for each acoustic Doppler Ocean velocimeter (ADV0) receiver at Site MD.

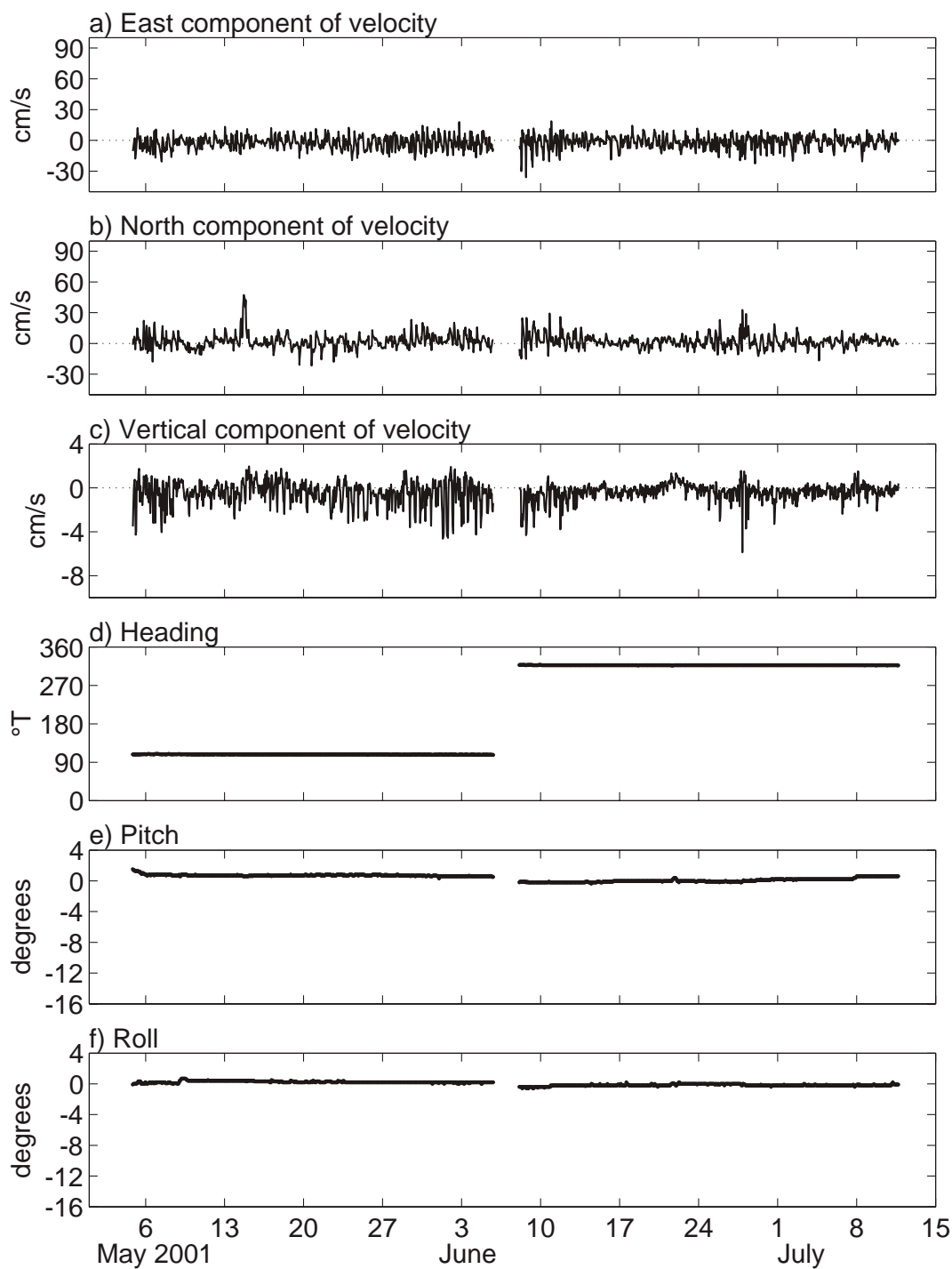


Figure 41. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MD. °T—degrees from true north.

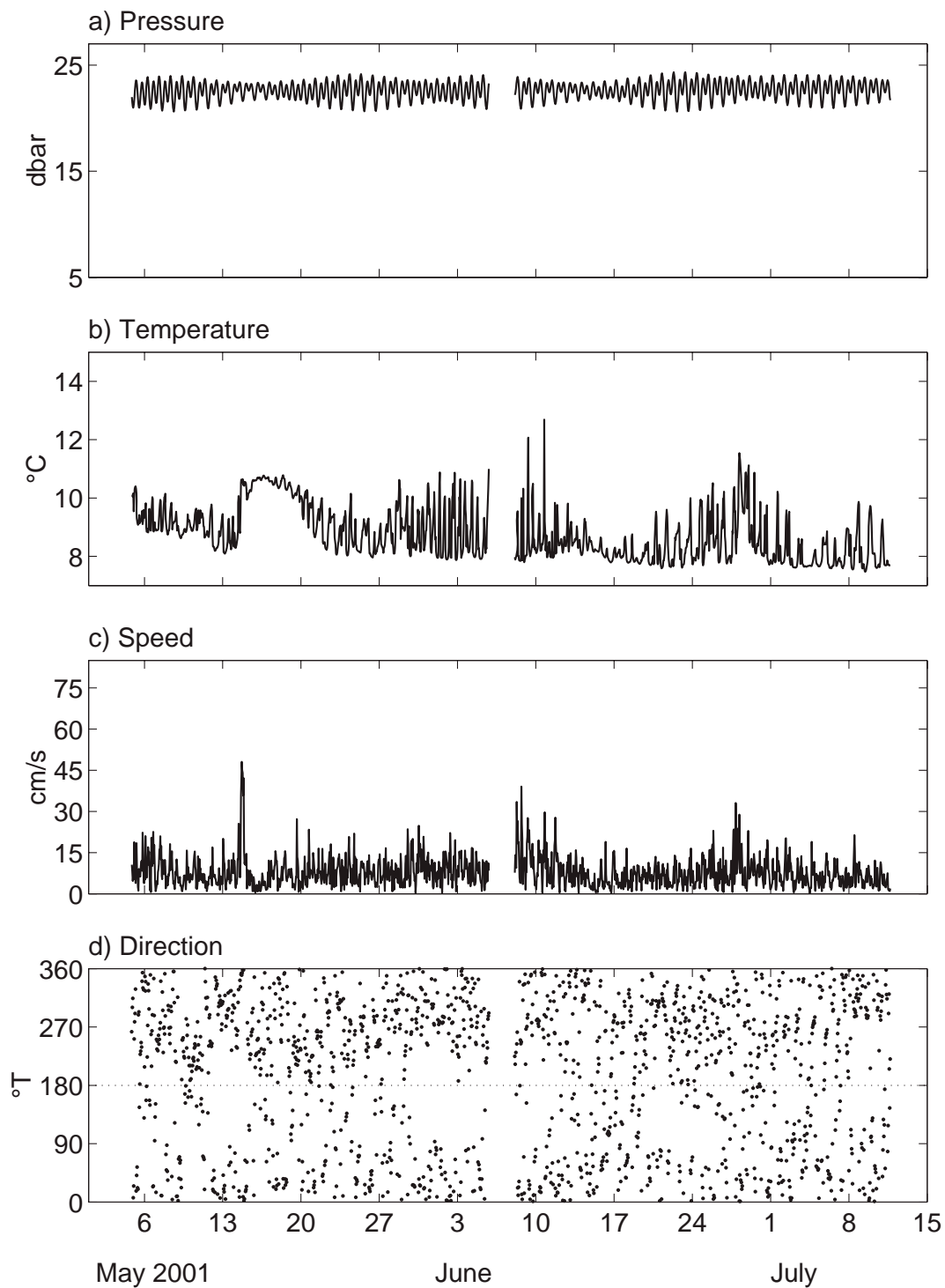


Figure 42. Time series of pressure, temperature, speed, and direction from the data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MD. °T—degrees from true north.

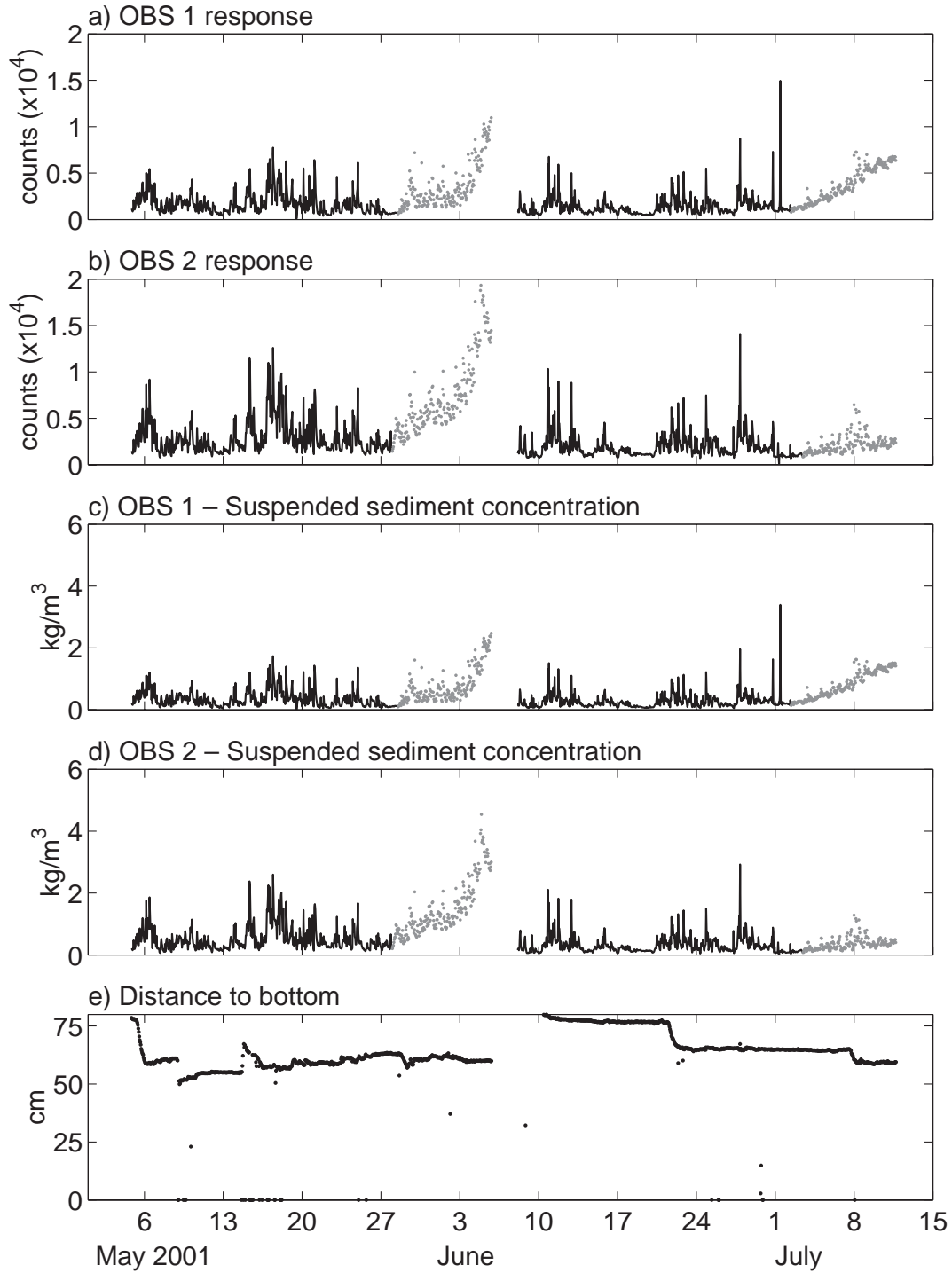


Figure 43. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MD. The entire OBS record is displayed; data influenced by biofouling is in grey. Distance to bottom is distance from the center of the ADVO sampling volume.

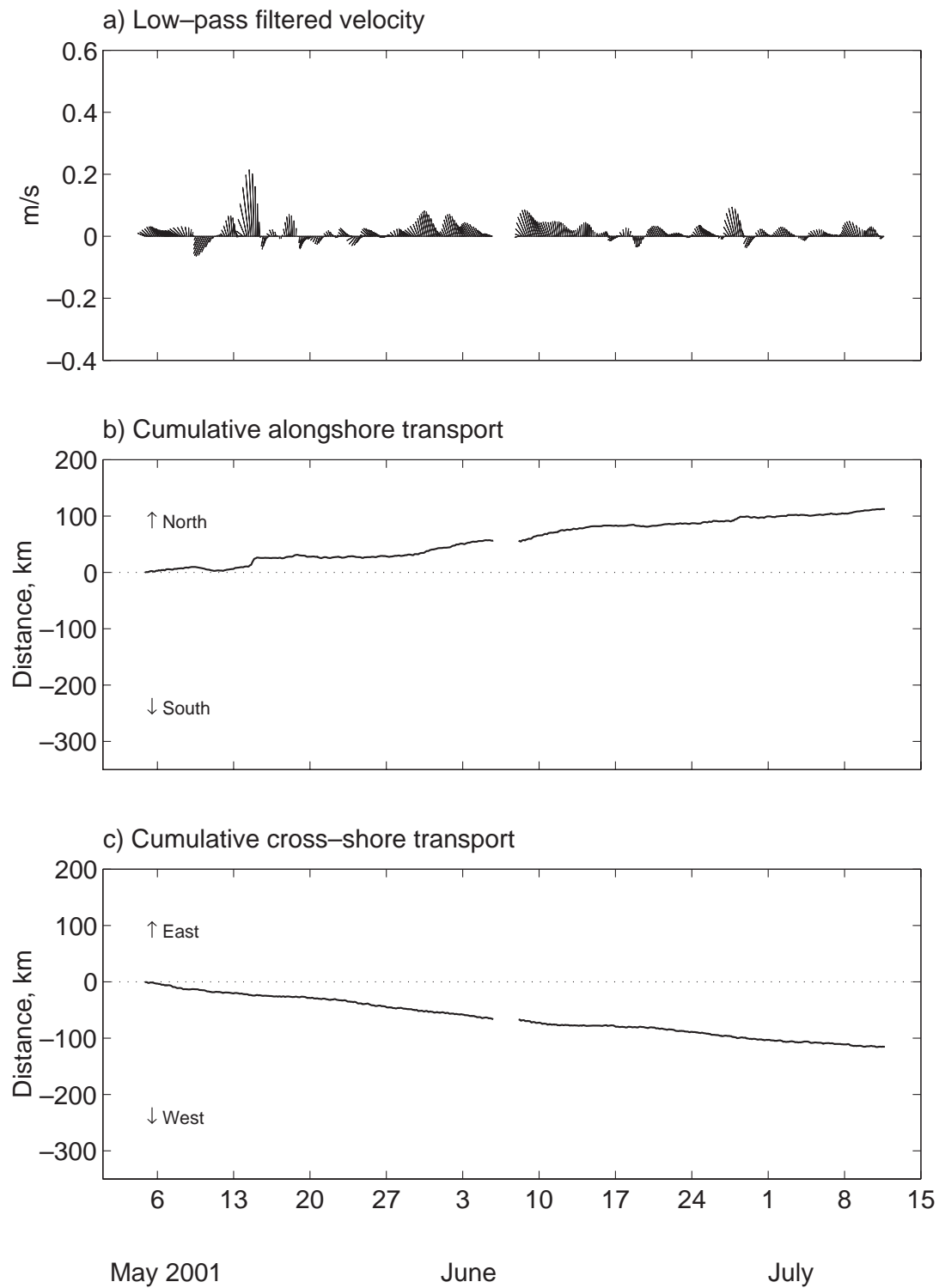


Figure 44. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for SiteMD.

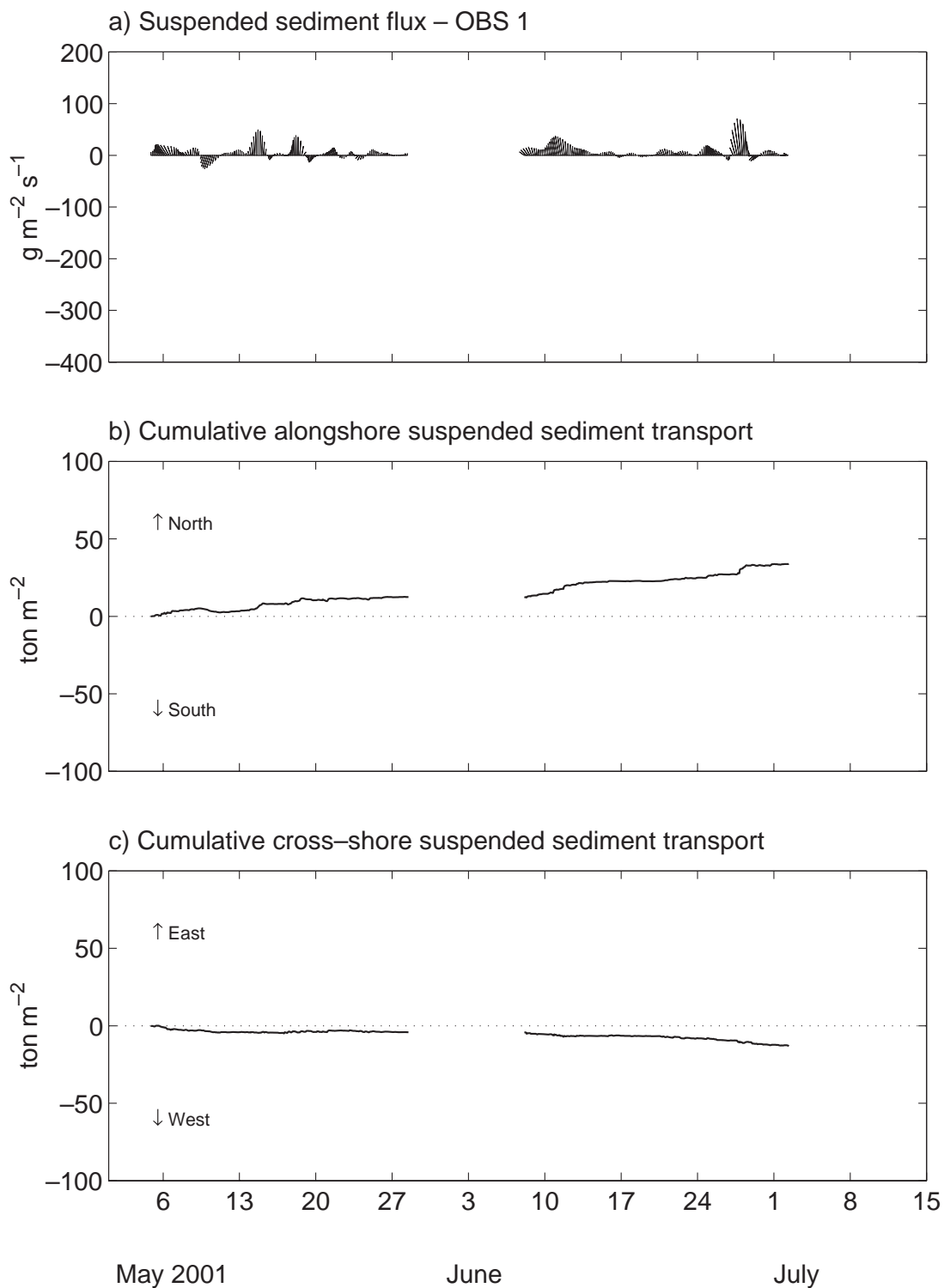


Figure 45. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Ocean velocimeter (ADV) data for Site MD. Time series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

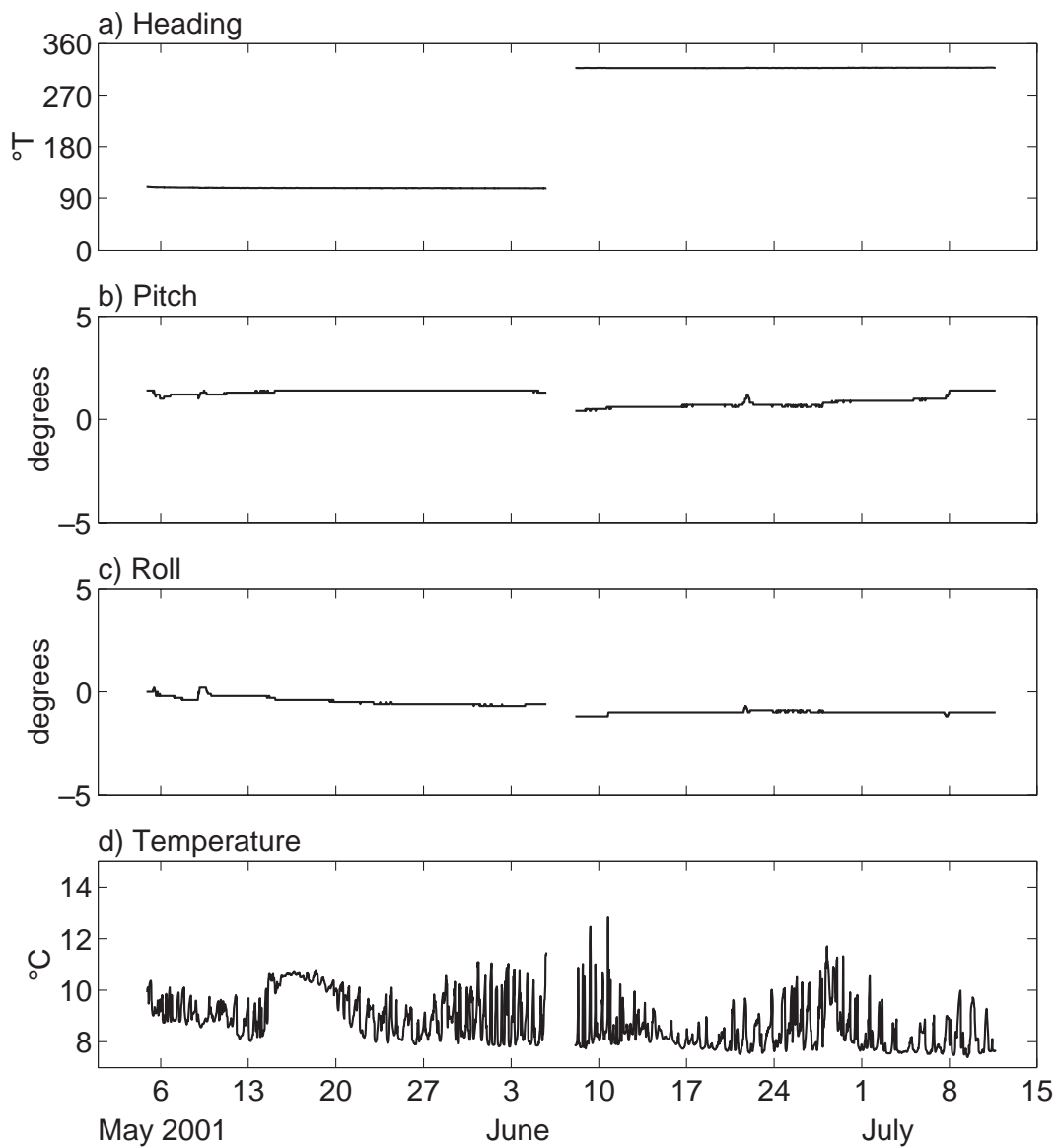


Figure 46. Time series of heading, pitch, roll, and temperature data collected by the acoustic Doppler profiler (ADP) at Site MD. $^{\circ}\text{T}$ —degrees from true north.

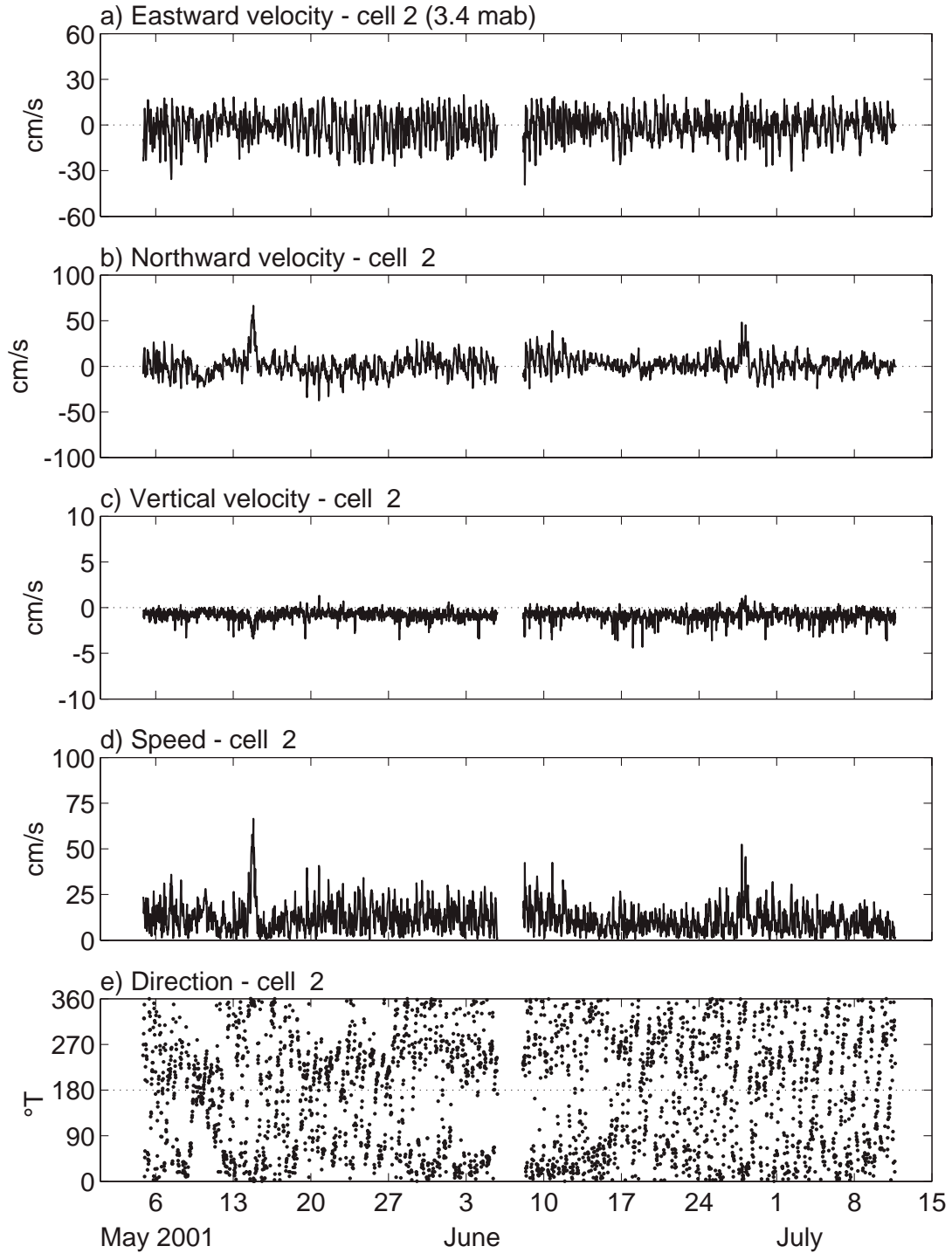


Figure 47. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 2 (3.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site MD. °T—degrees from true north.

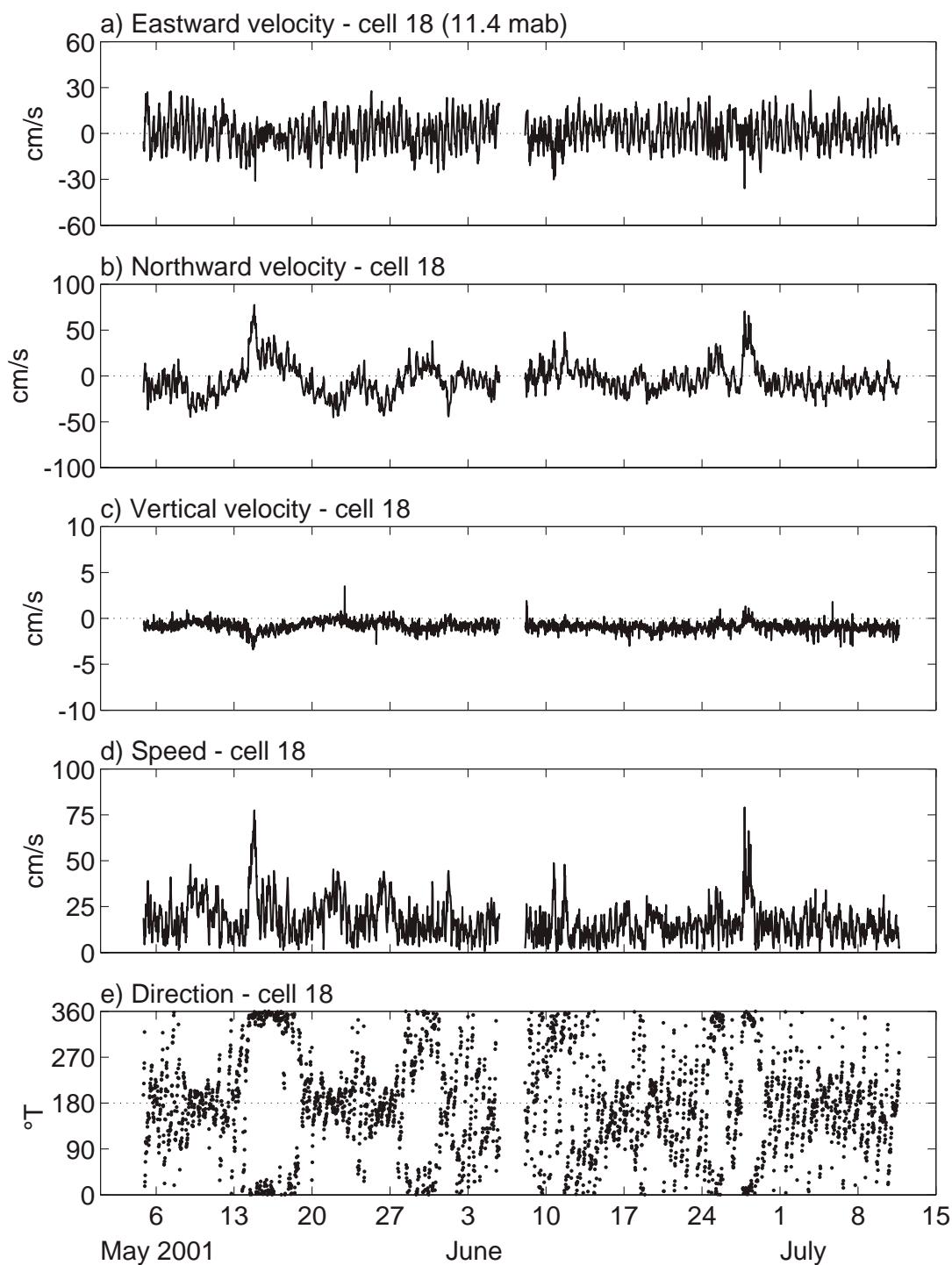


Figure 48. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 18 (11.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site MD. °T—degrees from true north.

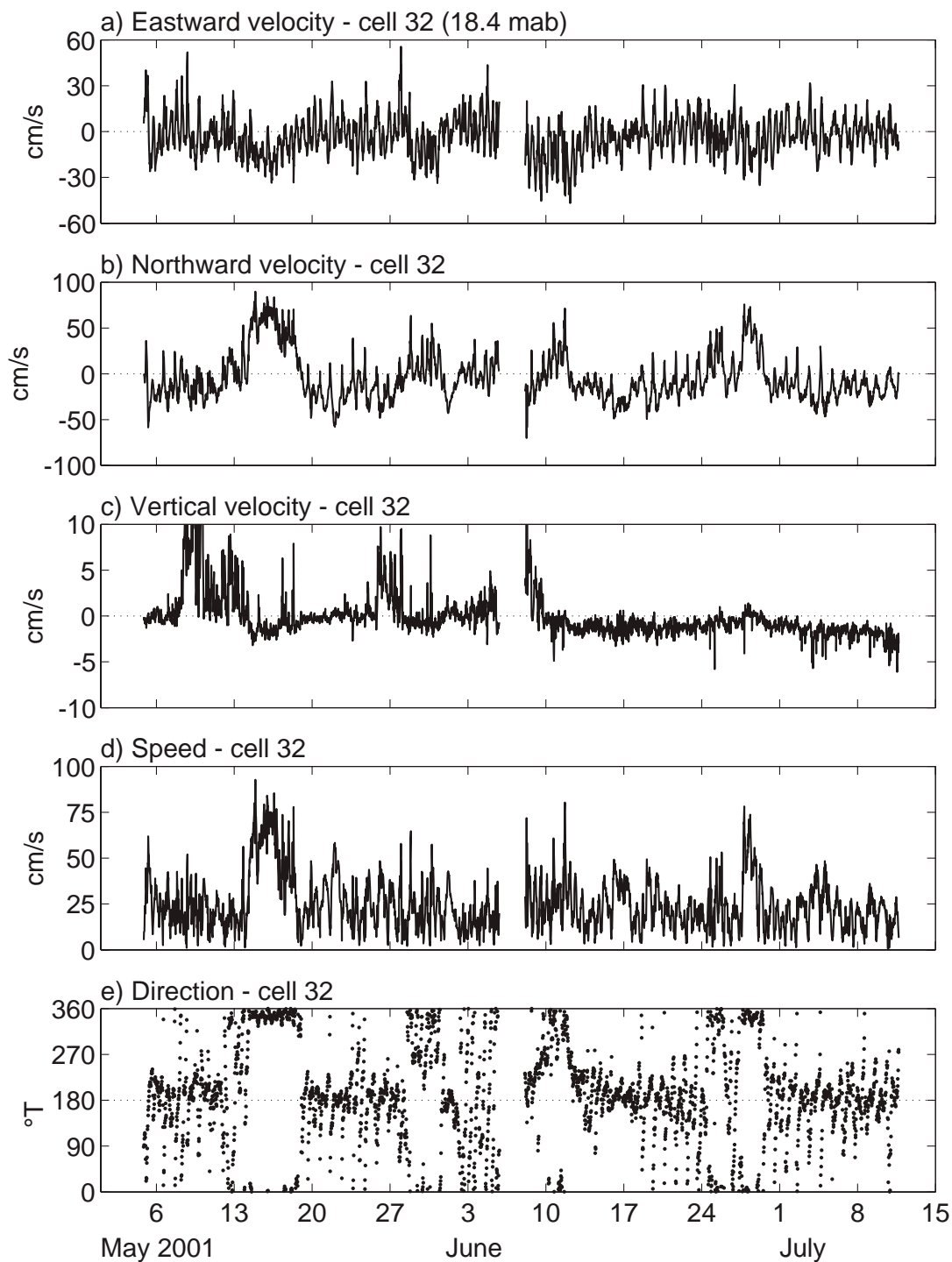


Figure 49. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 32 (18.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site MD. °T—degrees from true north.

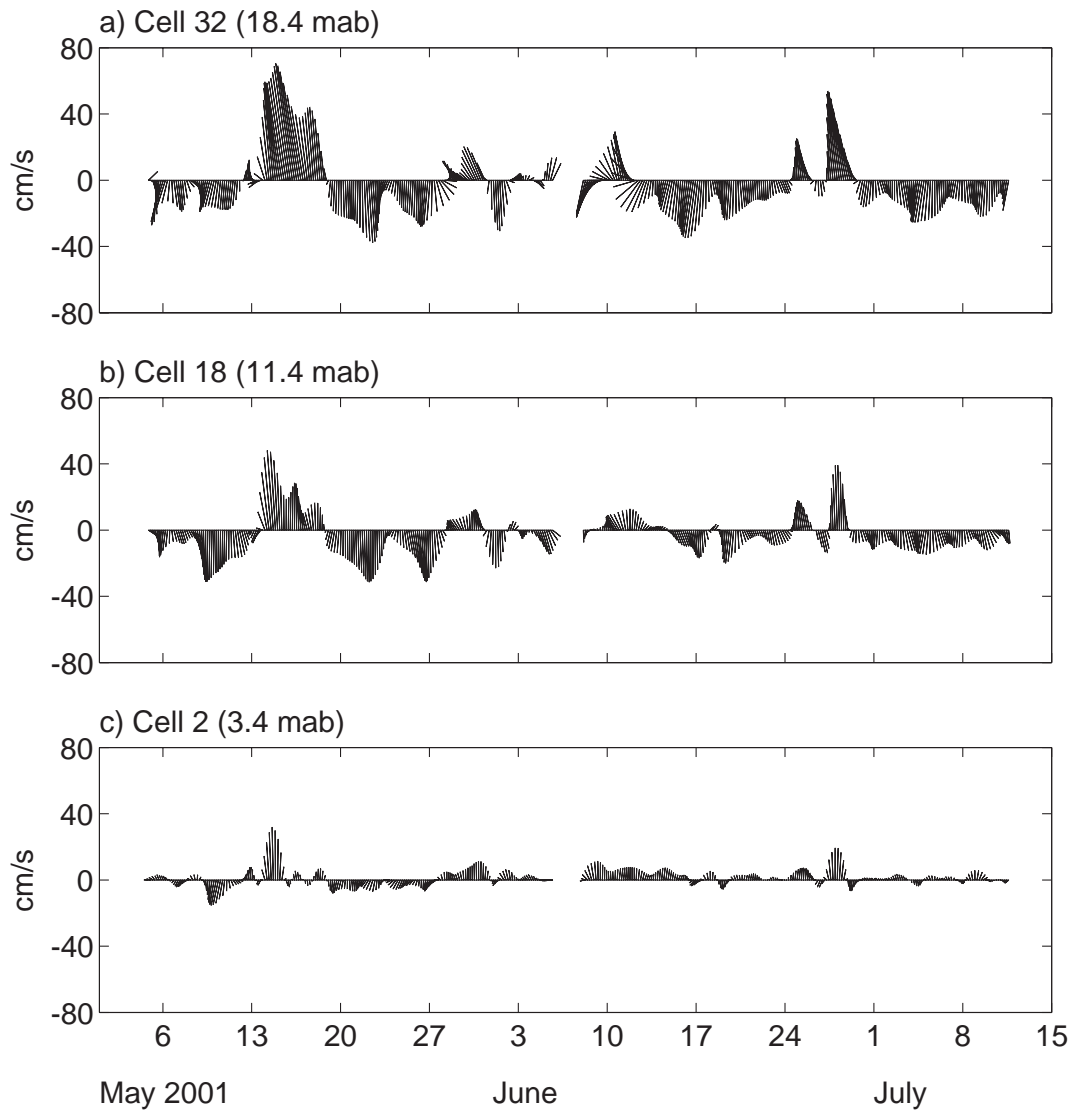


Figure 50. Time series of low-pass filtered velocity for several acoustic Doppler profiler (ADP) cells at Site MD. mab—meters above bed.

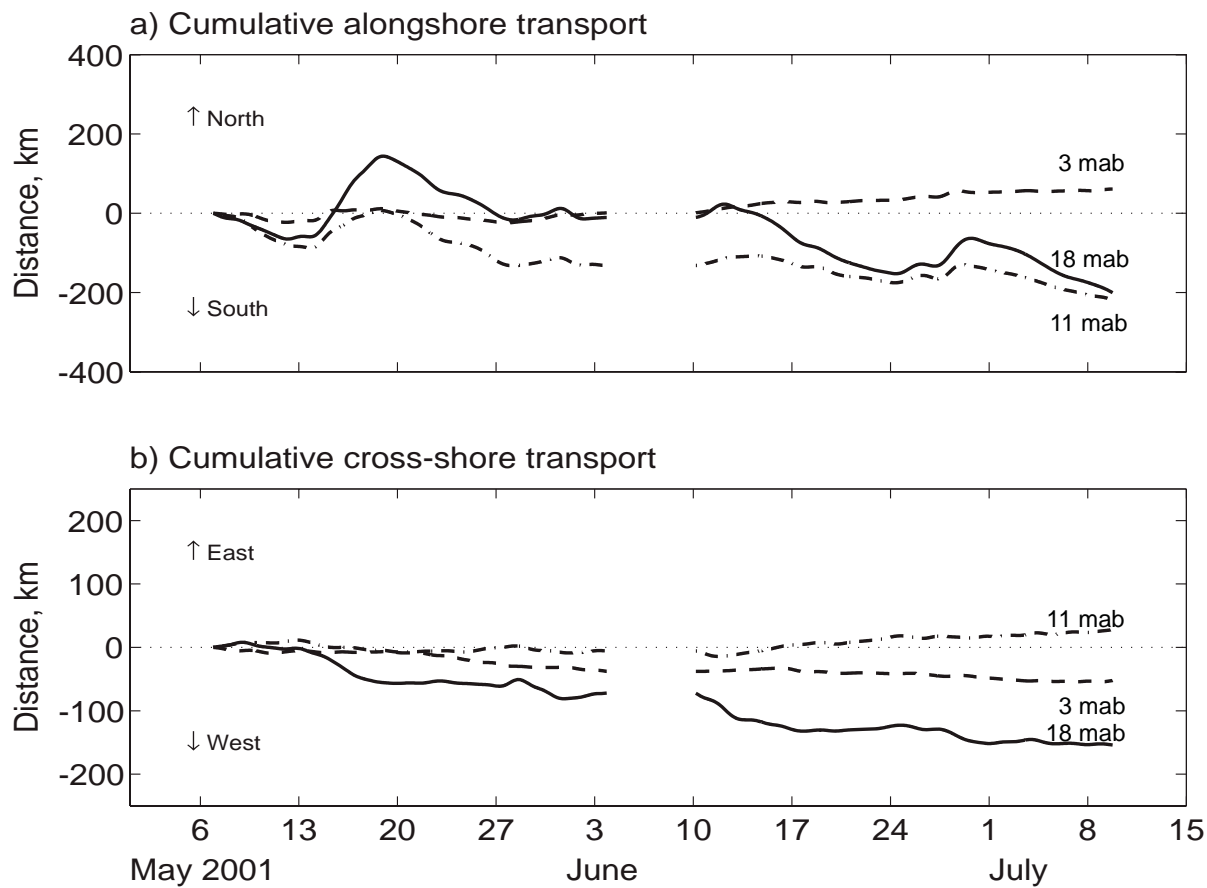


Figure 51. Time series of cumulative alongshore and cross-shore transport for several acoustic Doppler profiler (ADP) cells at Site MD. Data are presented at heights of approximately 3 (dashed line,--), 11 (dash-dotted line, -.), and 18 (solid line,-) mab (meters above bed).

3.3.3 Site MS

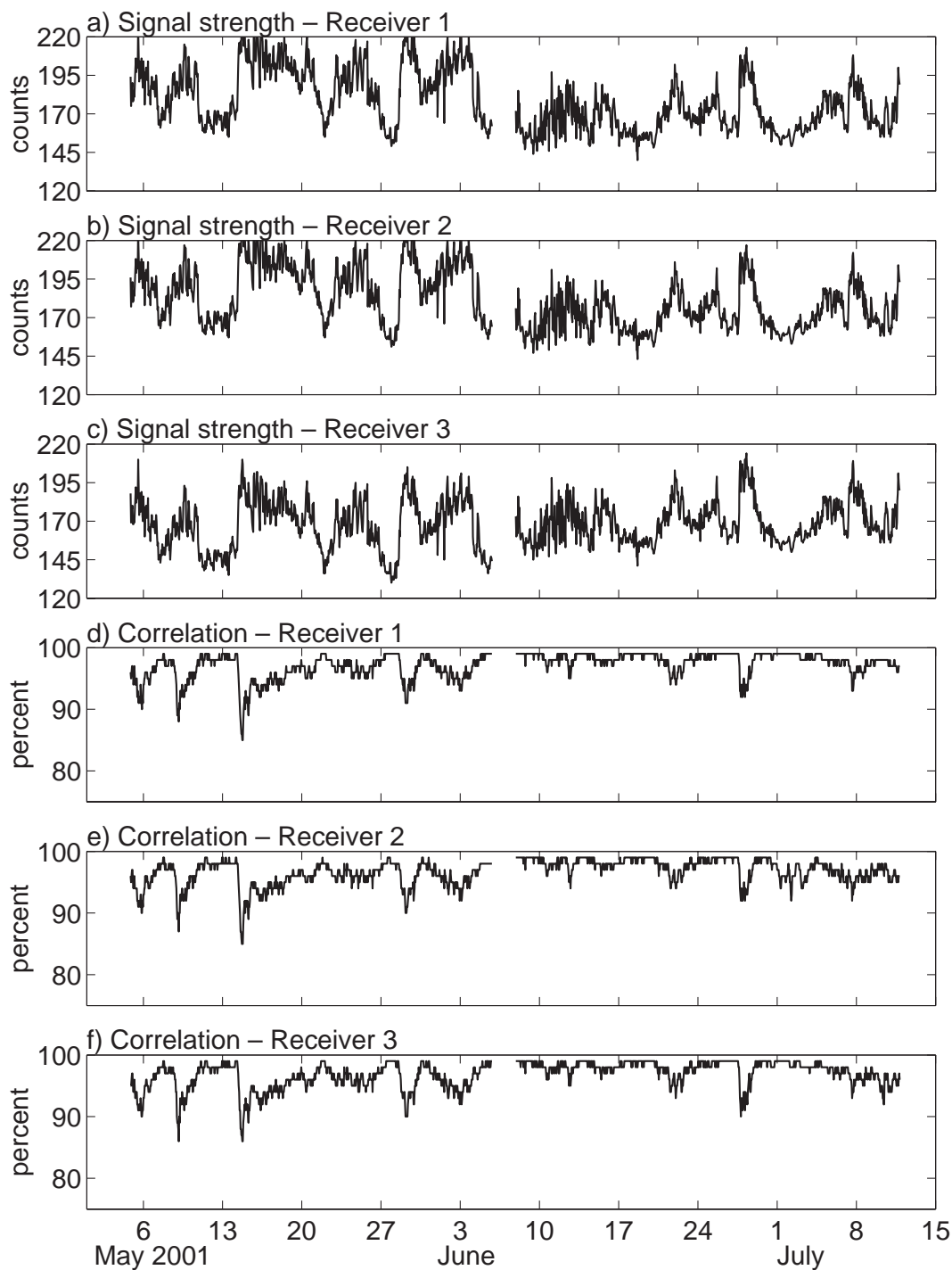


Figure 52. Time series of signal strength and signal correlation for each acoustic Doppler Ocean velocimeter (ADV0) receiver at Site MS.

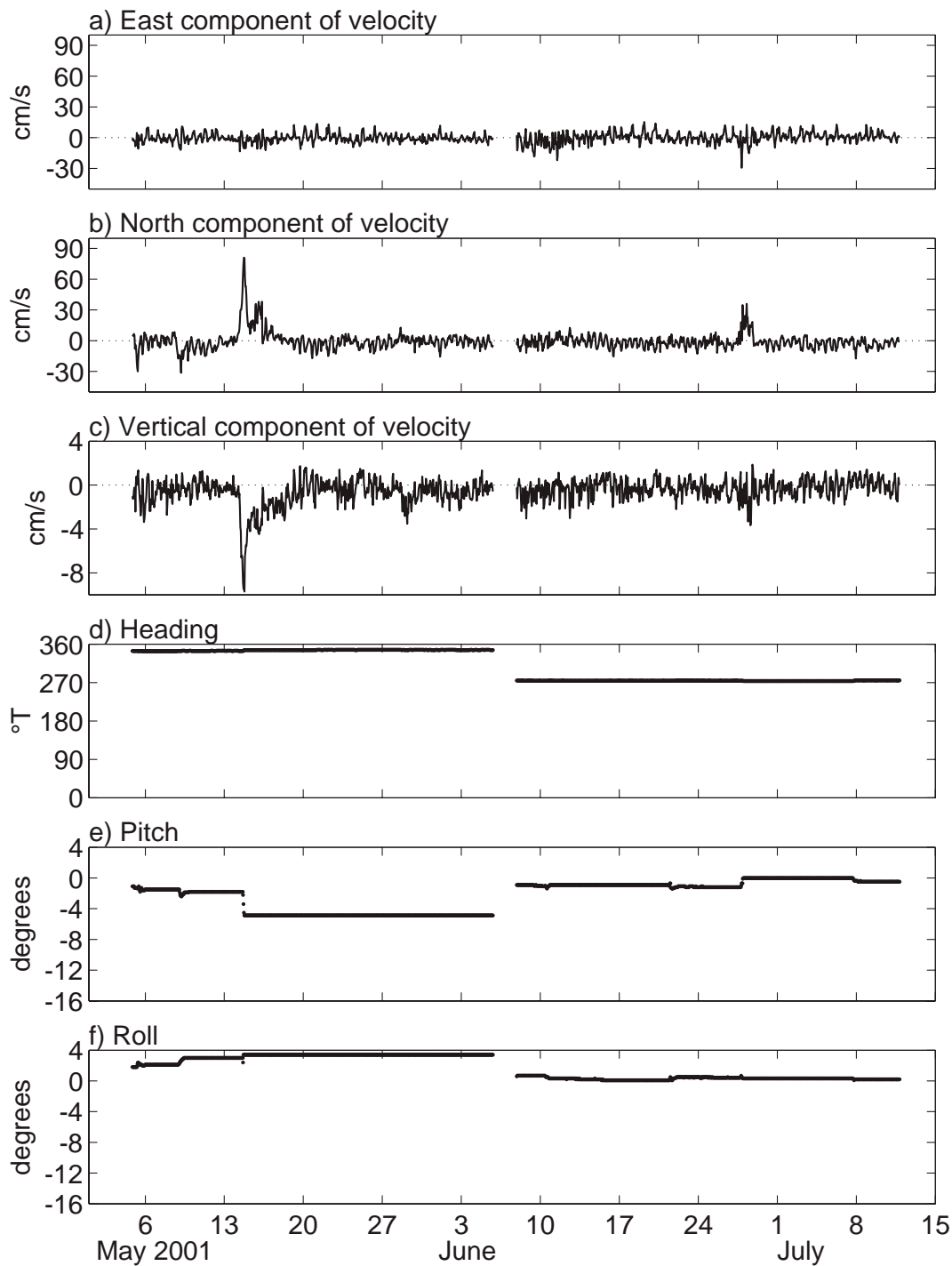


Figure 53. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MS. °T—degrees from true north.

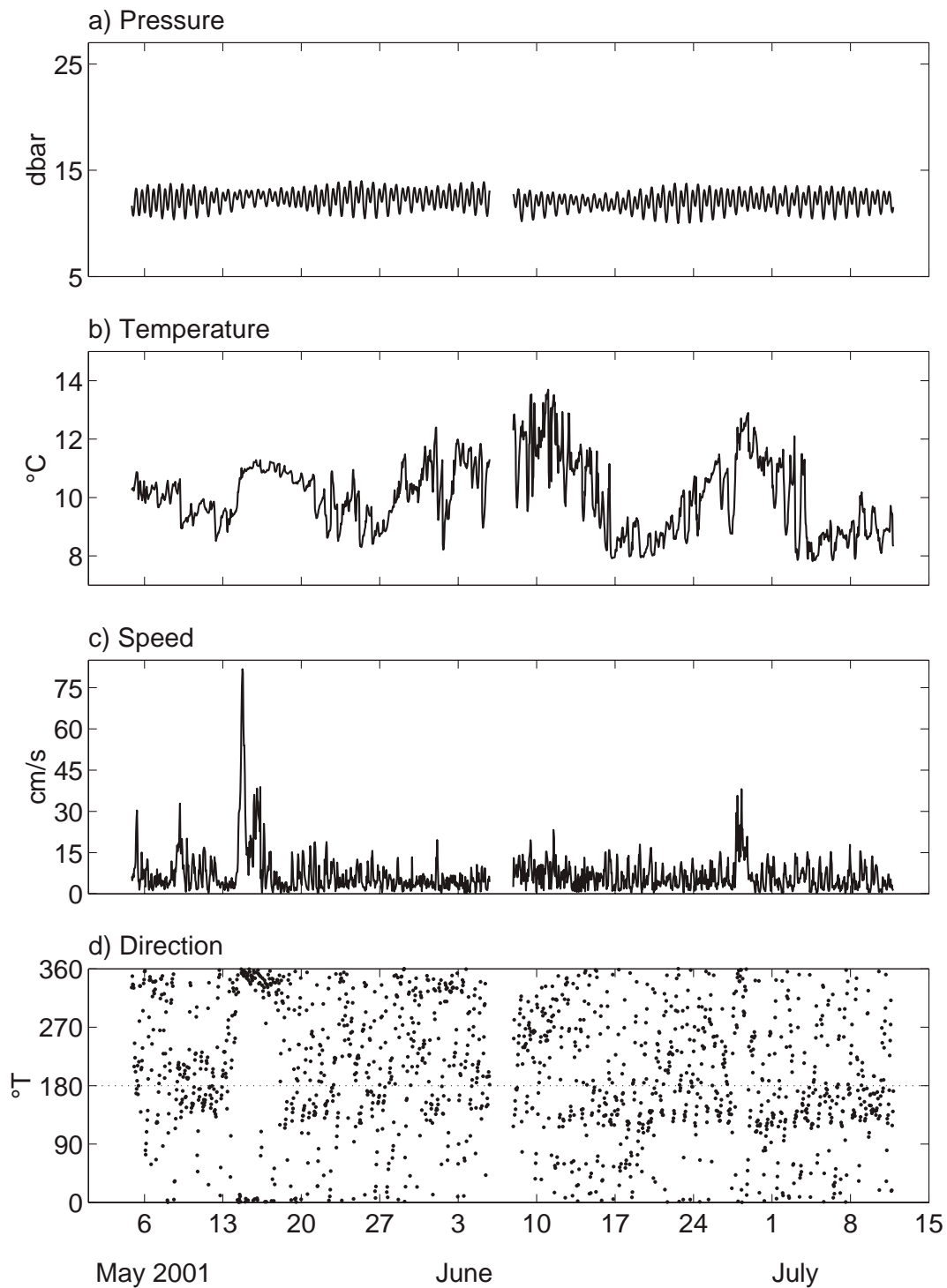


Figure 54. Time series of pressure, temperature, speed, and direction from the data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MS. °T—degrees from true north.

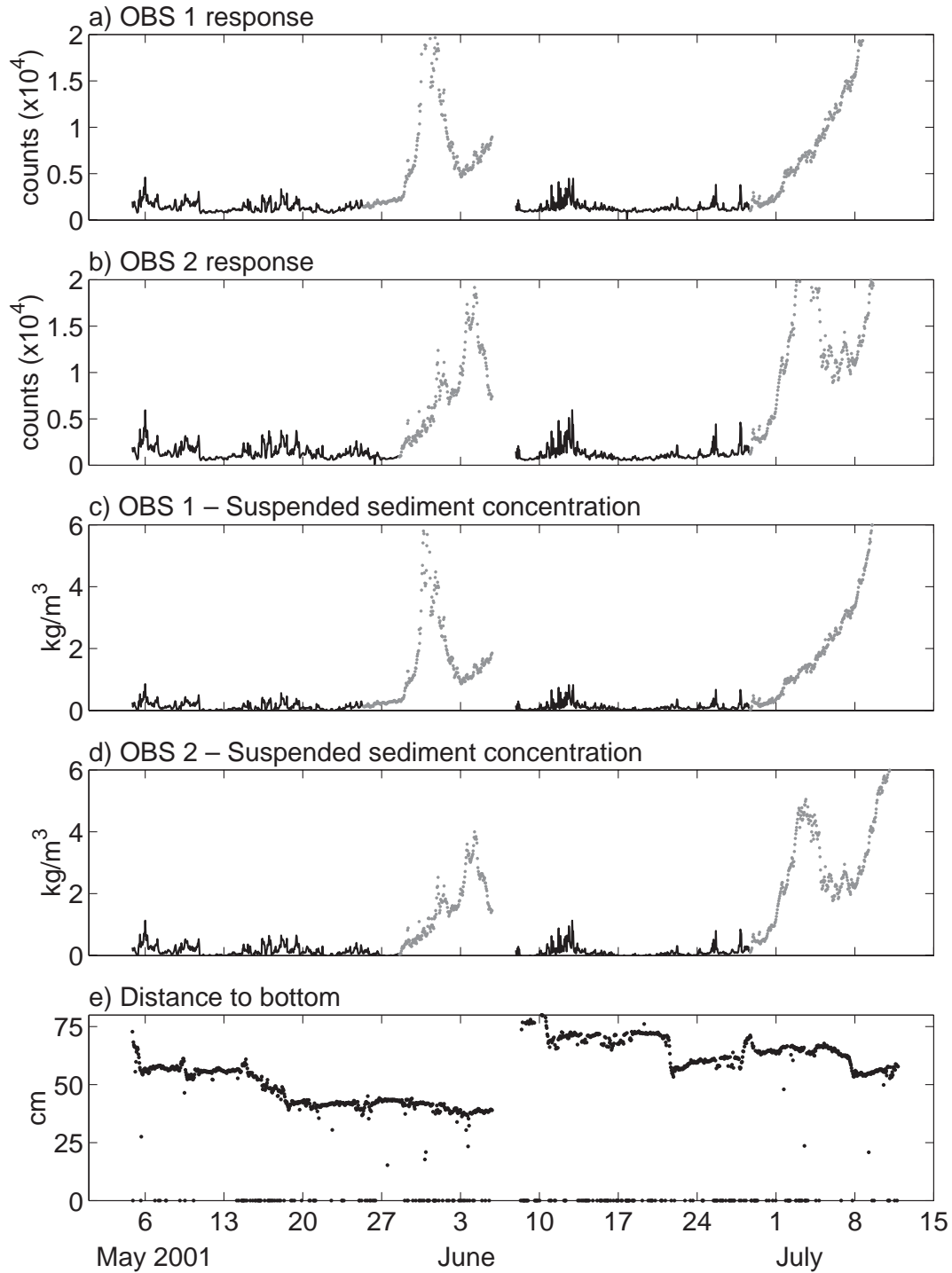


Figure 55. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MS. The entire OBS record is displayed; data influenced by biofouling is in grey. Distance to bottom is distance from the center of the ADVO sampling volume.

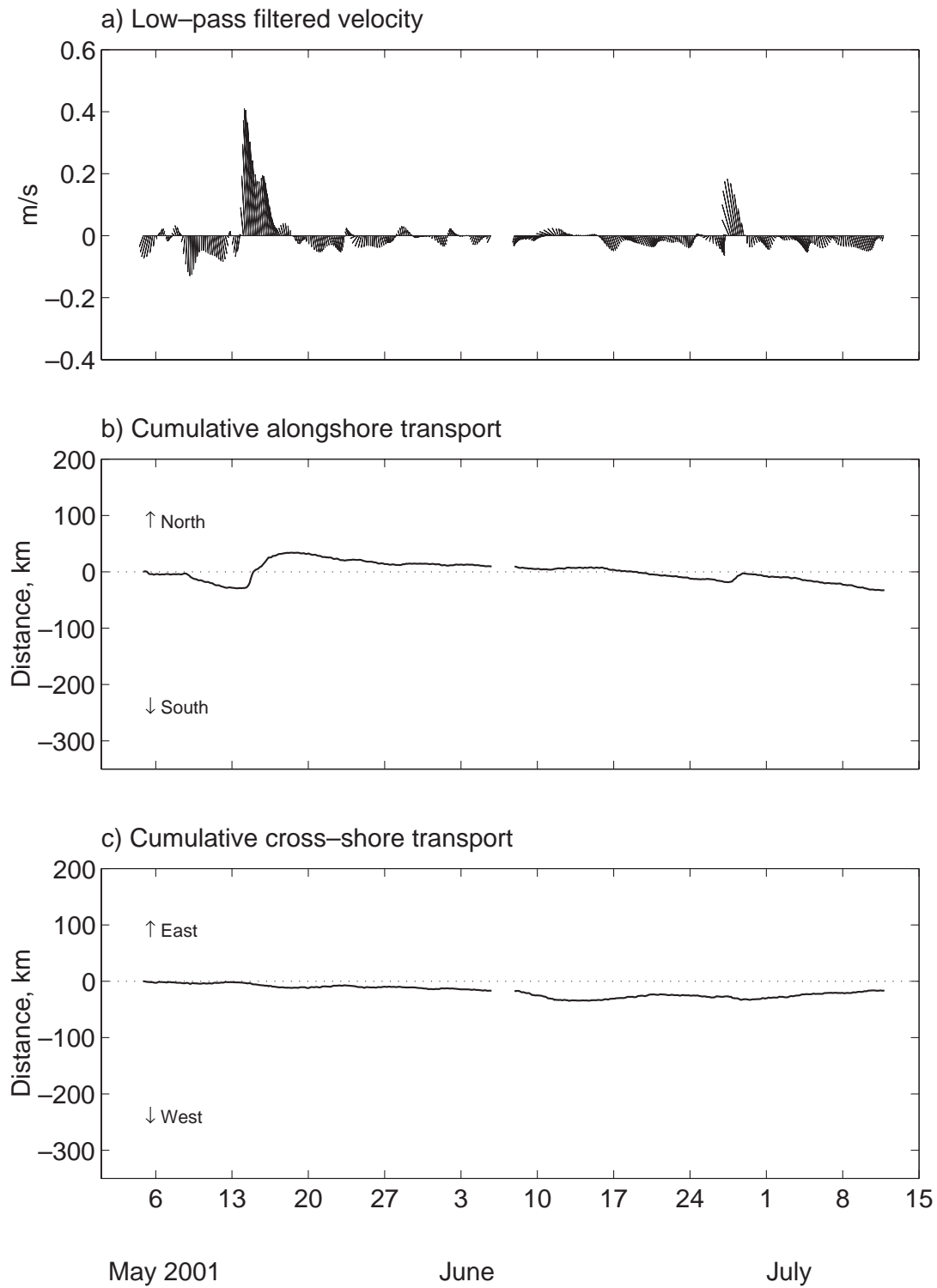


Figure 56. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site MS.

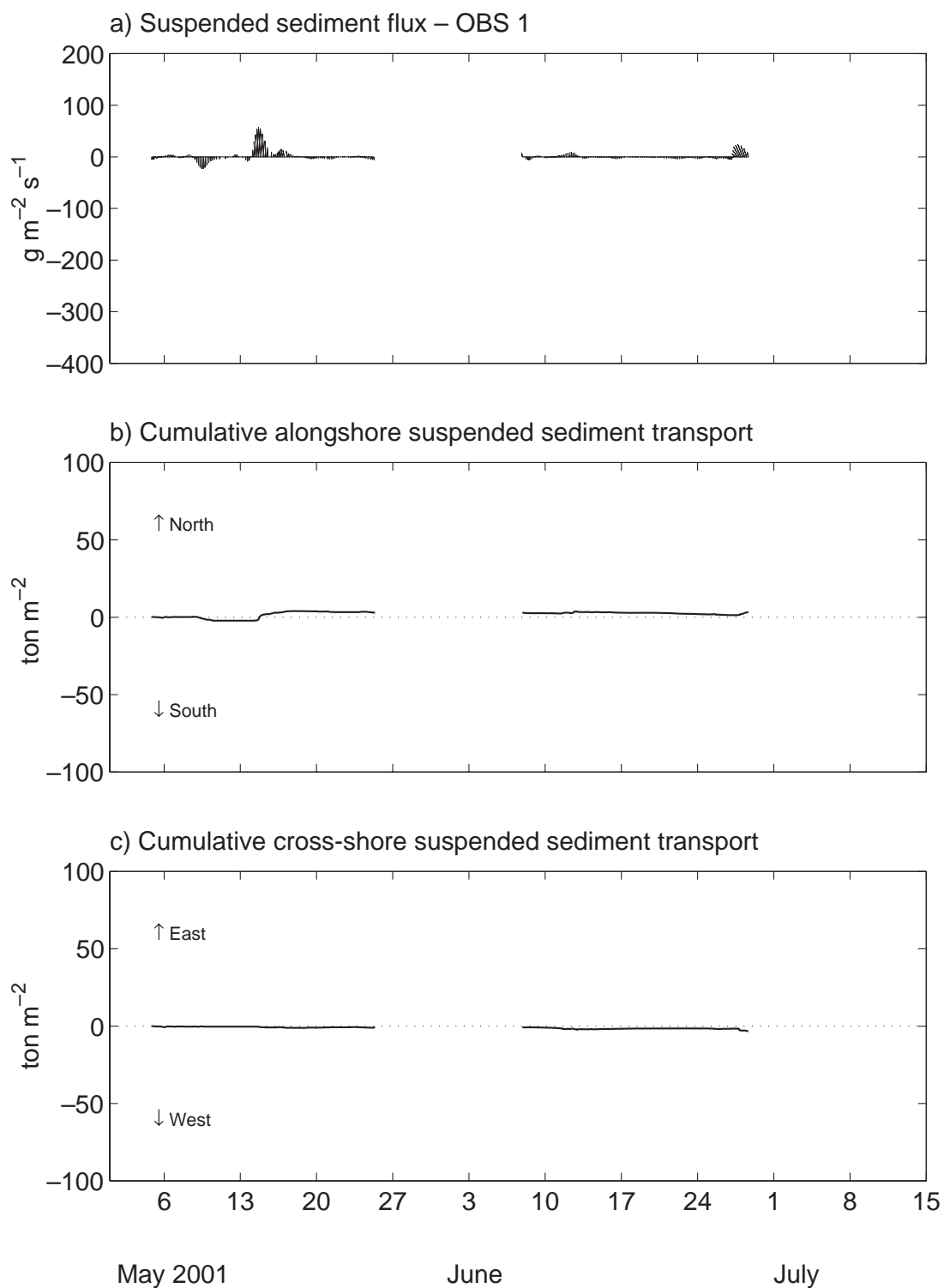


Figure 57. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Ocean velocimeter (ADV0) data for Site MS. Times series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

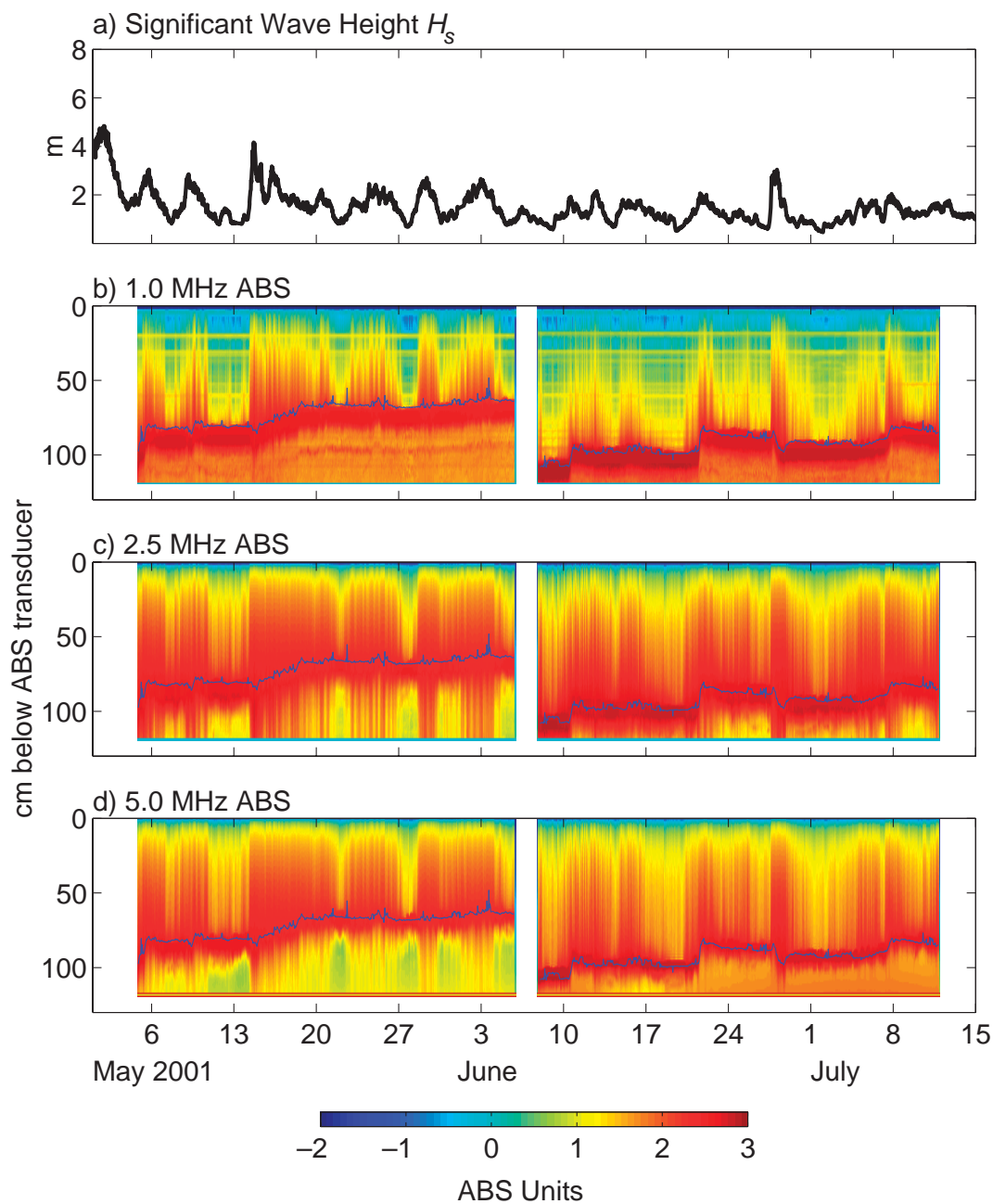


Figure 58. Time series of significant wave height as reported by the Coastal Data Information Program (CDIP) wave buoy, and the uncalibrated response of each frequency of acoustic backscatter system (ABS) deployed at Site MS. Distance to bottom (blue line) time series from the acoustic Doppler Ocean velocimeter (ADV0) data from Site MS is plotted on top of the ABS data.

3.3.4 Site MIA

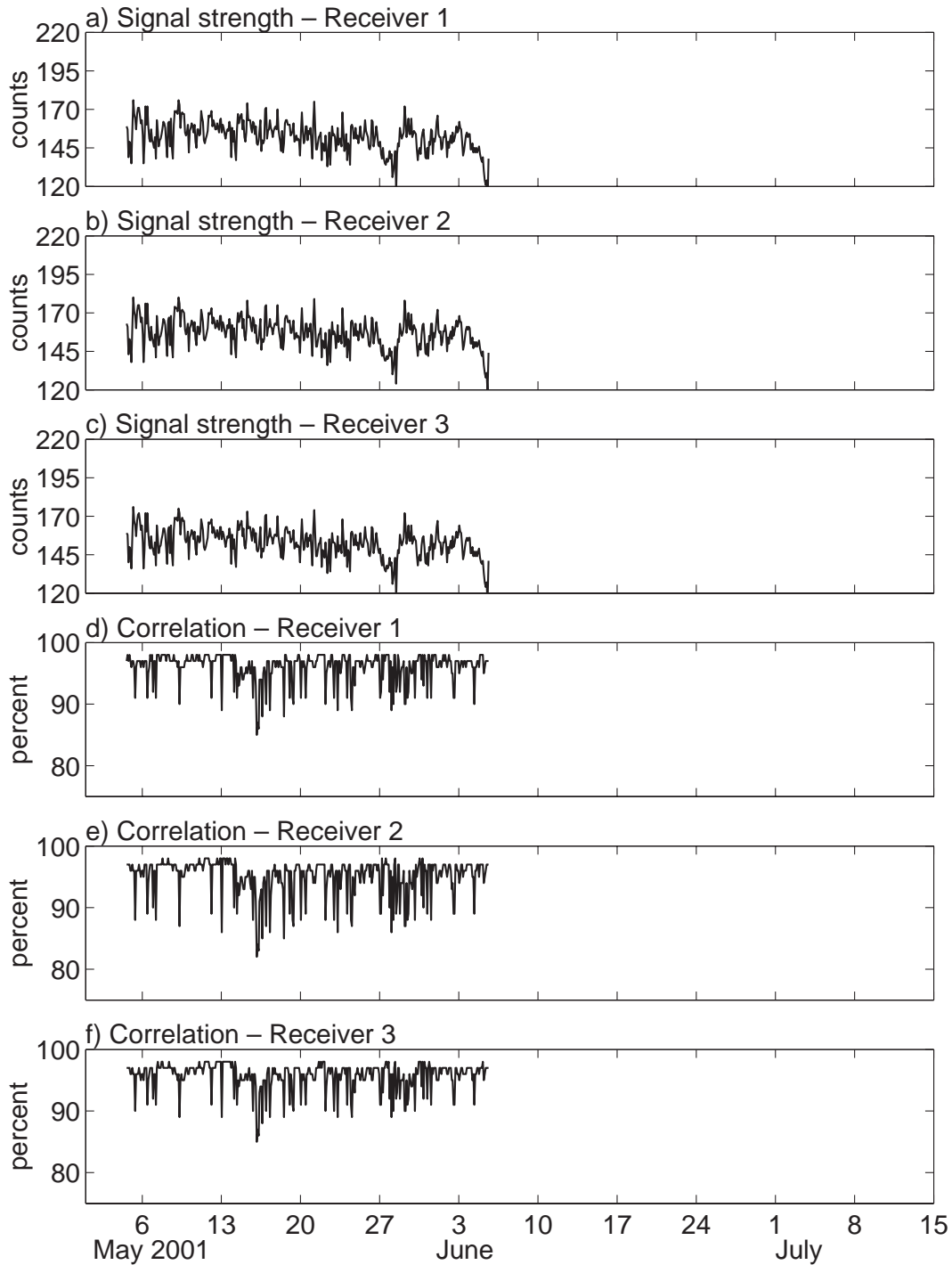


Figure 59. Time series of signal strength and signal correlation for each acoustic Doppler Field velocimeter (ADVF), serial number 231, receiver at Site MIA.

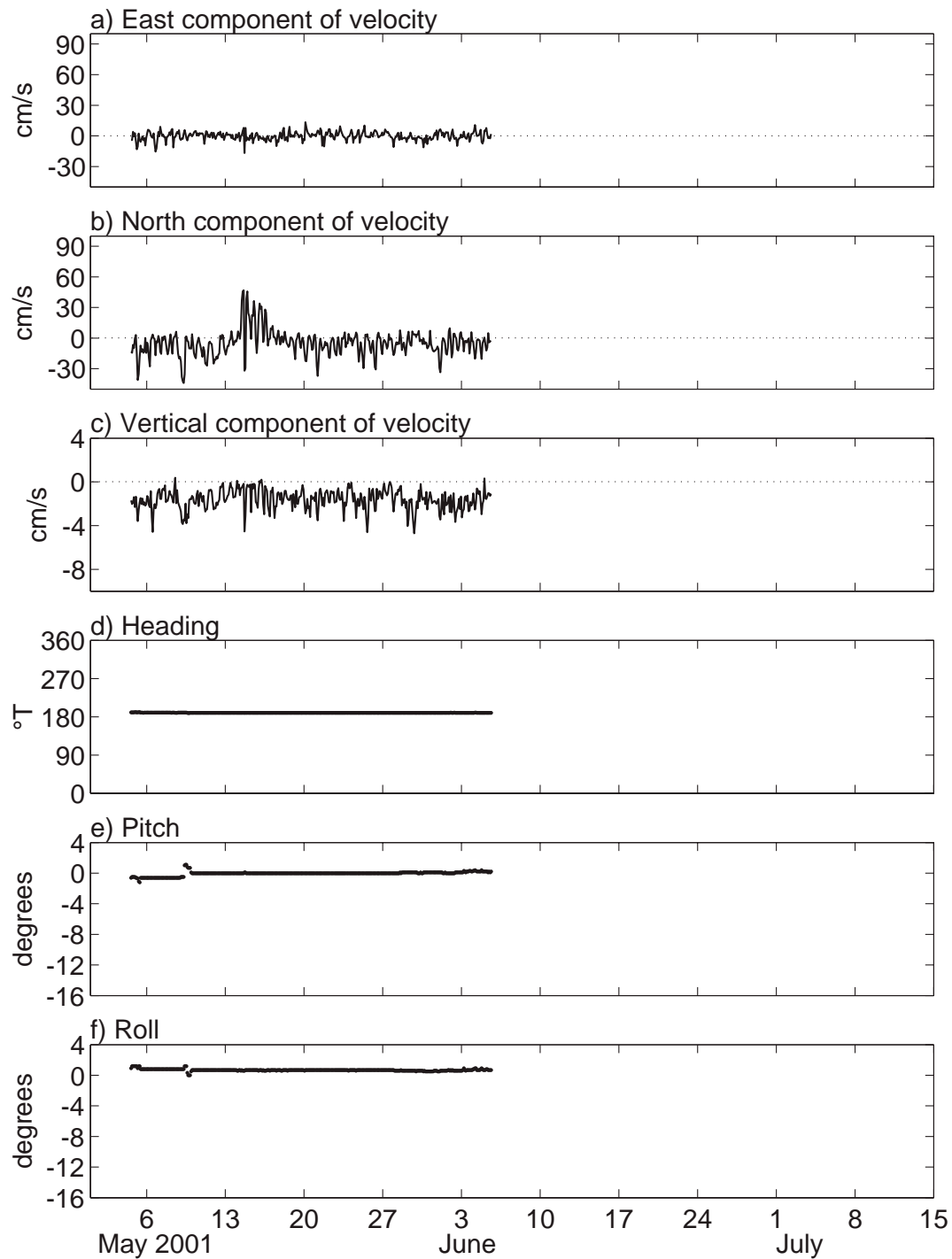


Figure 60. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 231, at Site MIA. °T—degrees from true north.

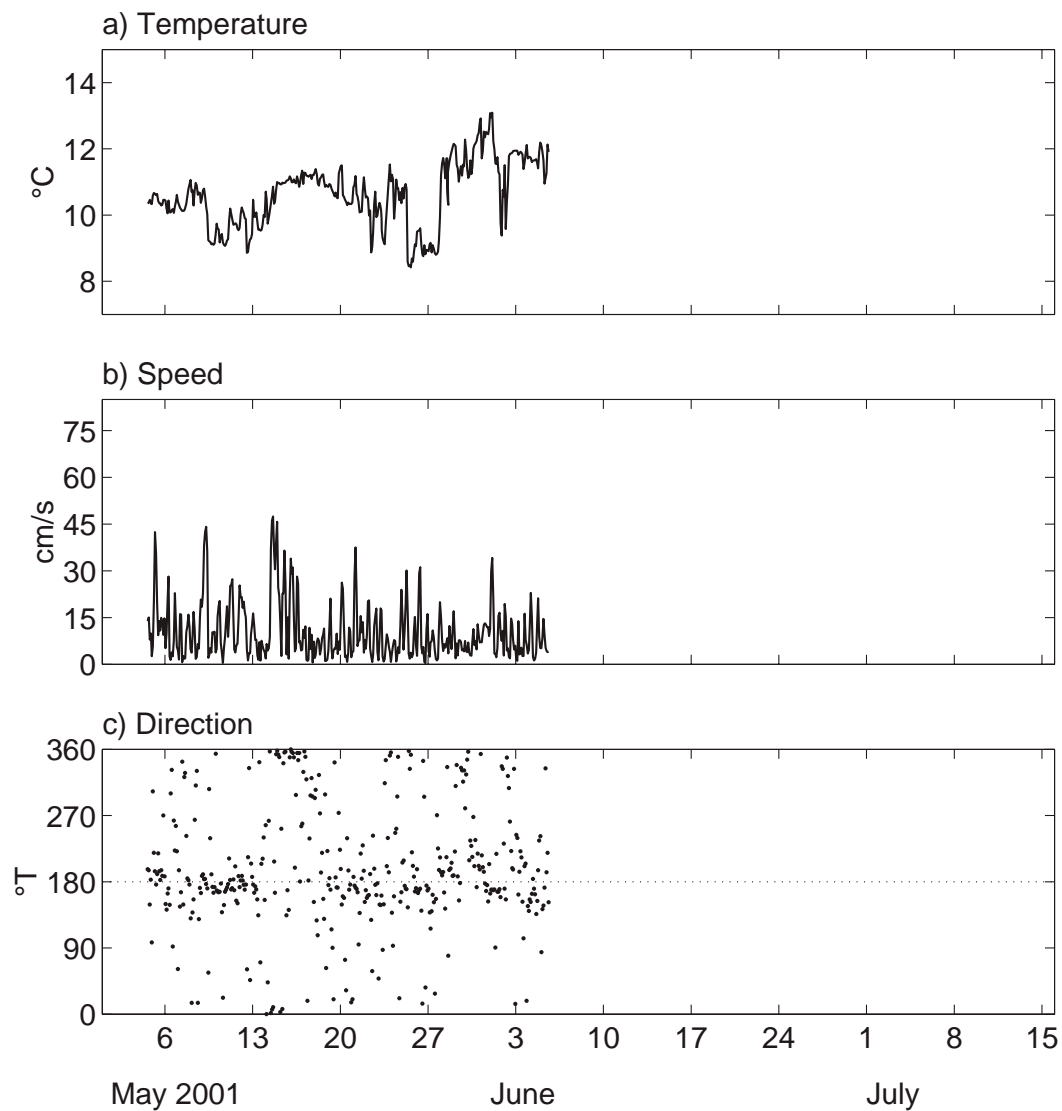


Figure 61. Time series of temperature, speed, and direction from the data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 231, at Site MIA. $^{\circ}\text{T}$ —degrees from true north.

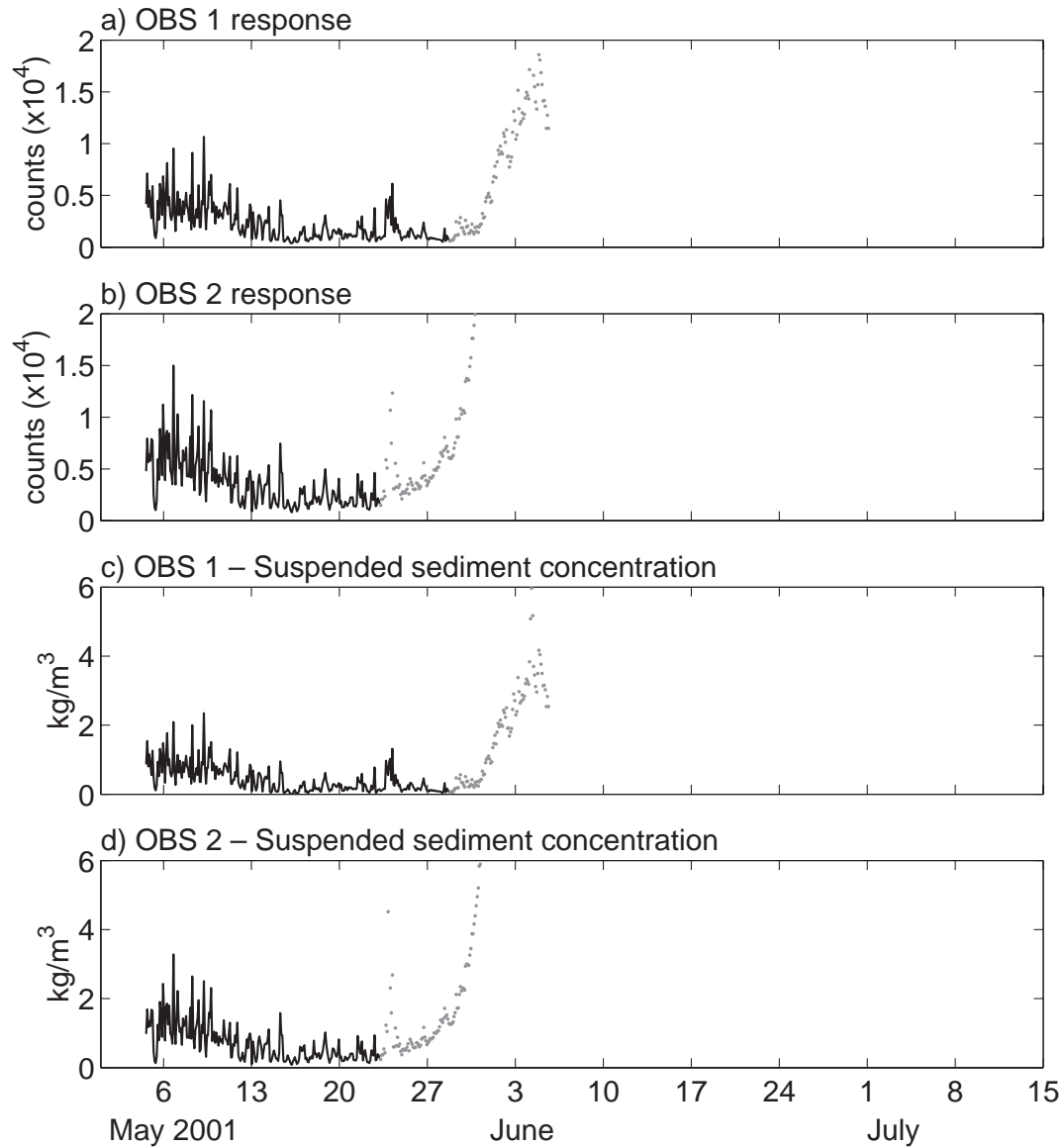


Figure 62. Time series of raw optical backscatter (OBS) data, and calibrated OBS data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 231, at Site MIA. The entire OBS record is displayed; data influenced by biofouling is in grey.

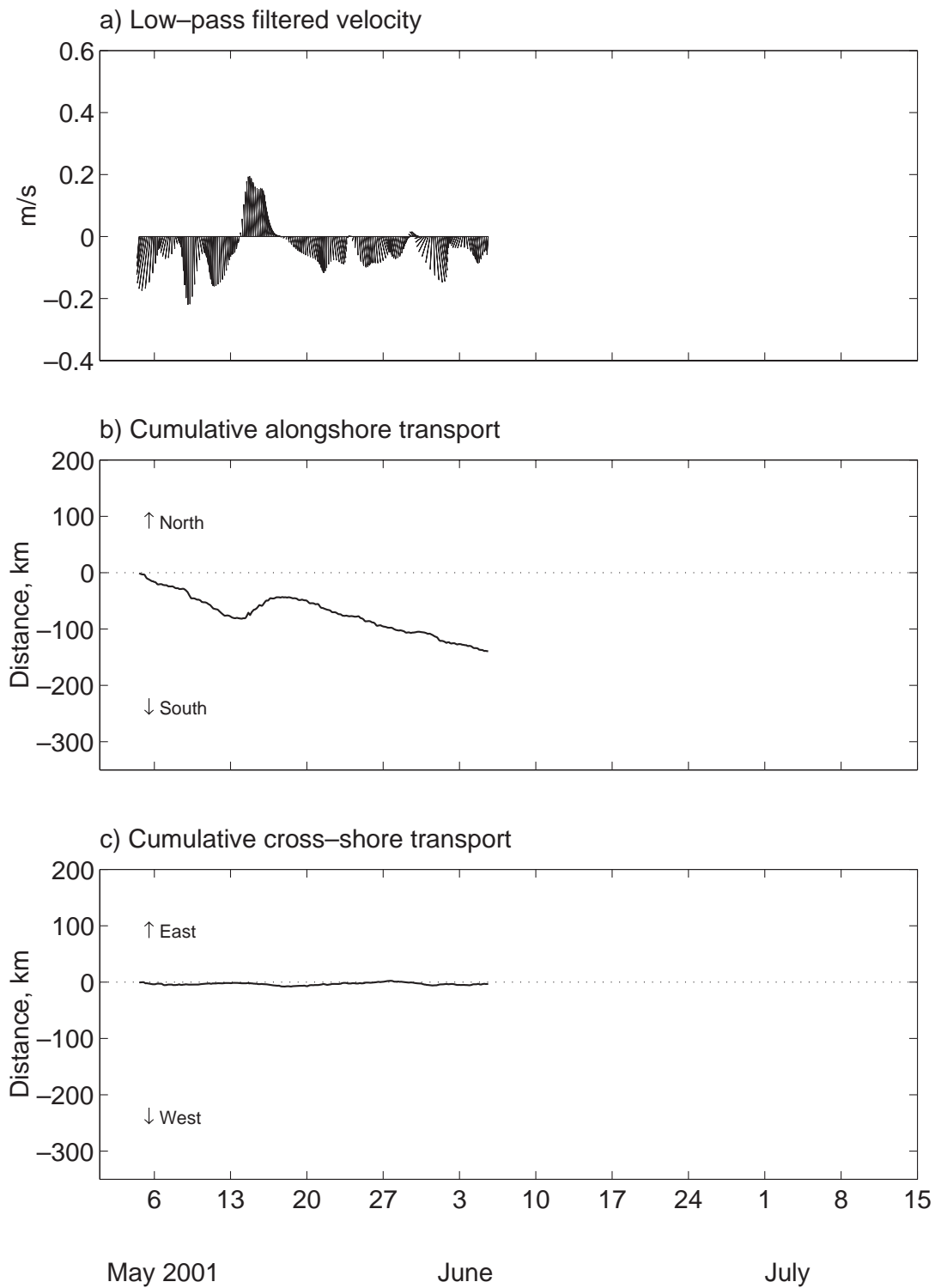


Figure 63. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Field velocimeter (ADVF), serial number 231, data for Site MIA.

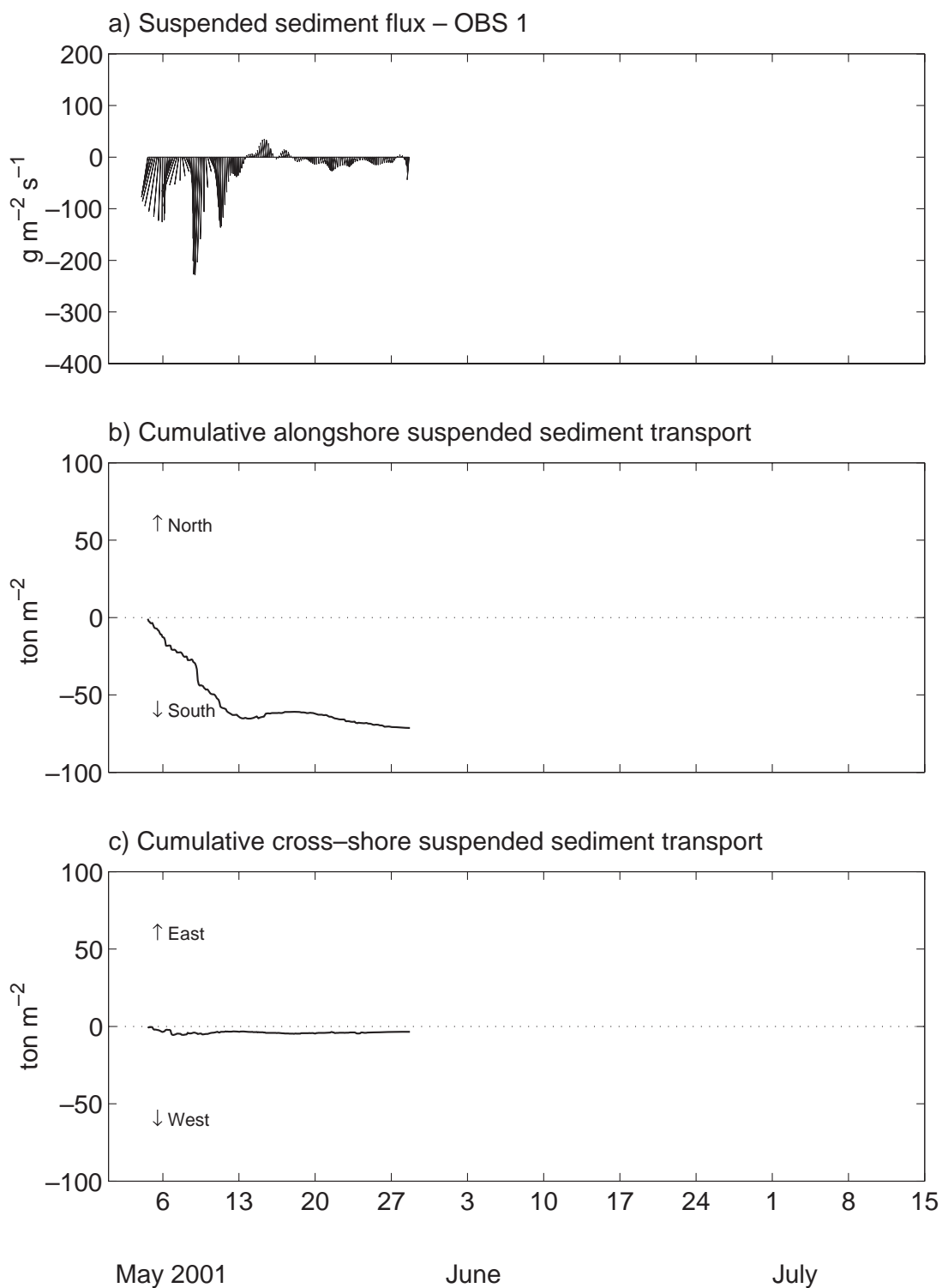


Figure 64. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Field velocimeter (ADVF), serial number 231, data for Site MIA. Times series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

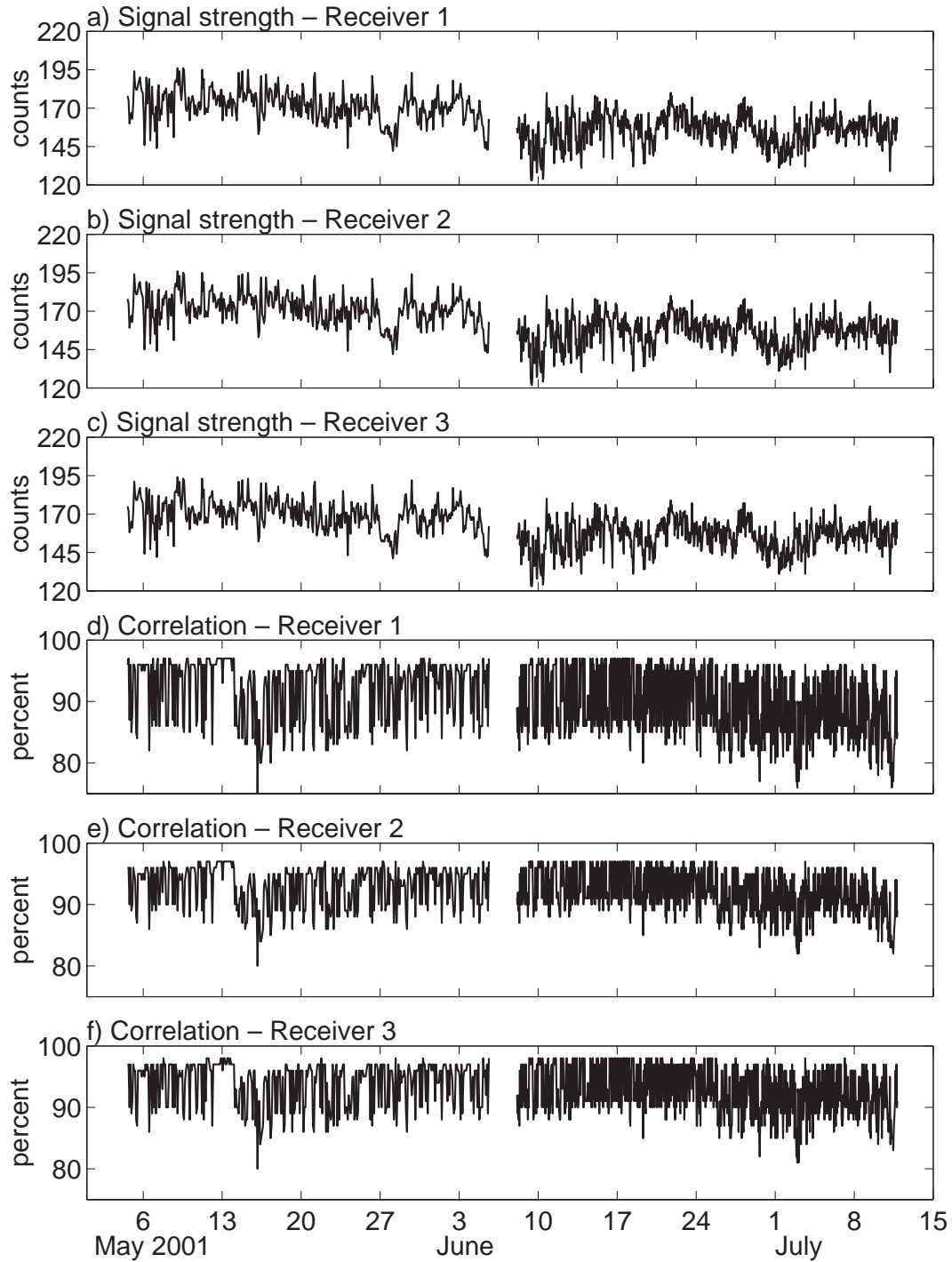


Figure 65. Time series of signal strength and signal correlation for each acoustic Doppler Field velocimeter (ADVF), serial number 244, receiver at Site MIA.

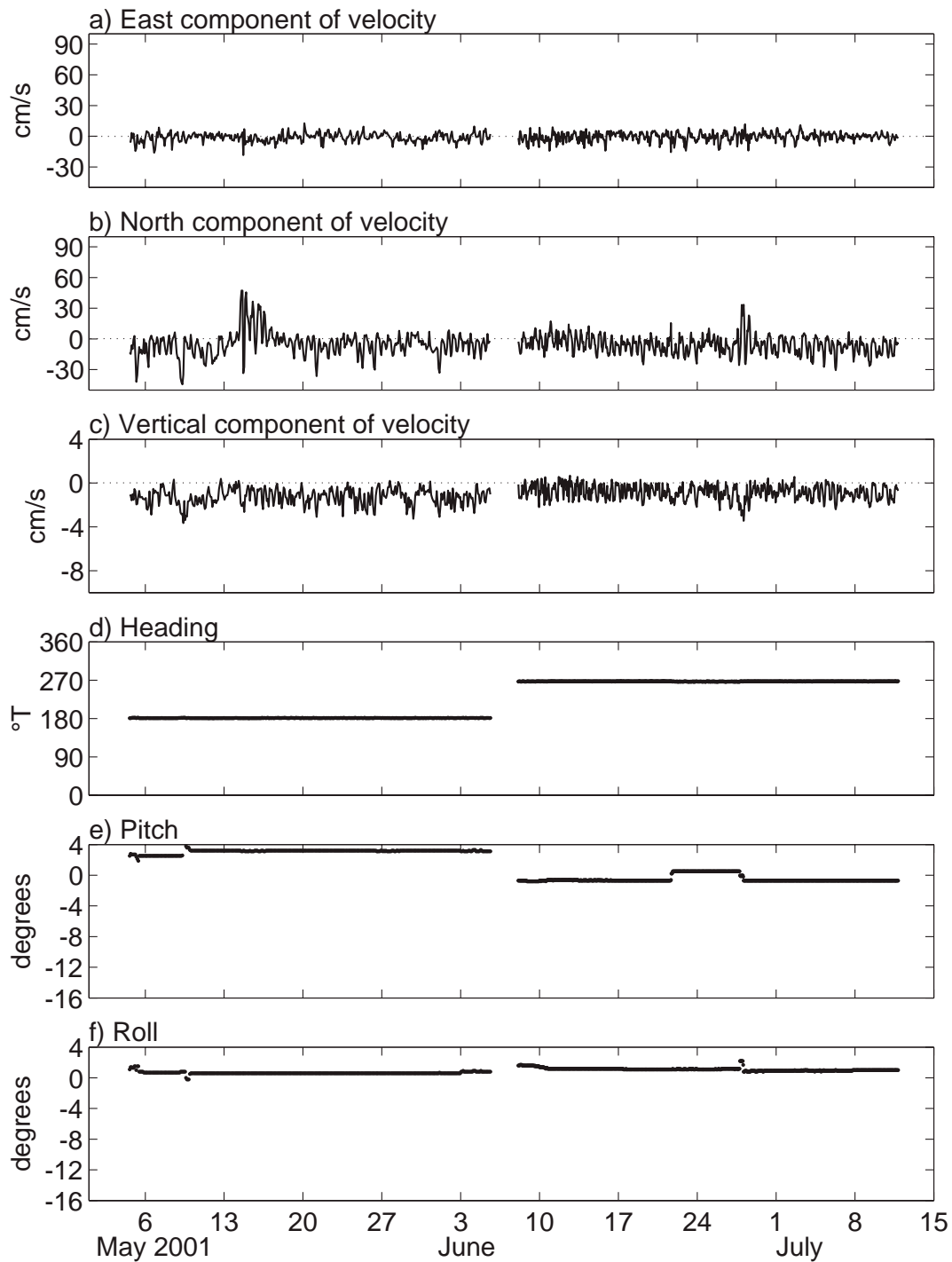


Figure 66. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 244, at Site MIA. °T—degrees from true north.

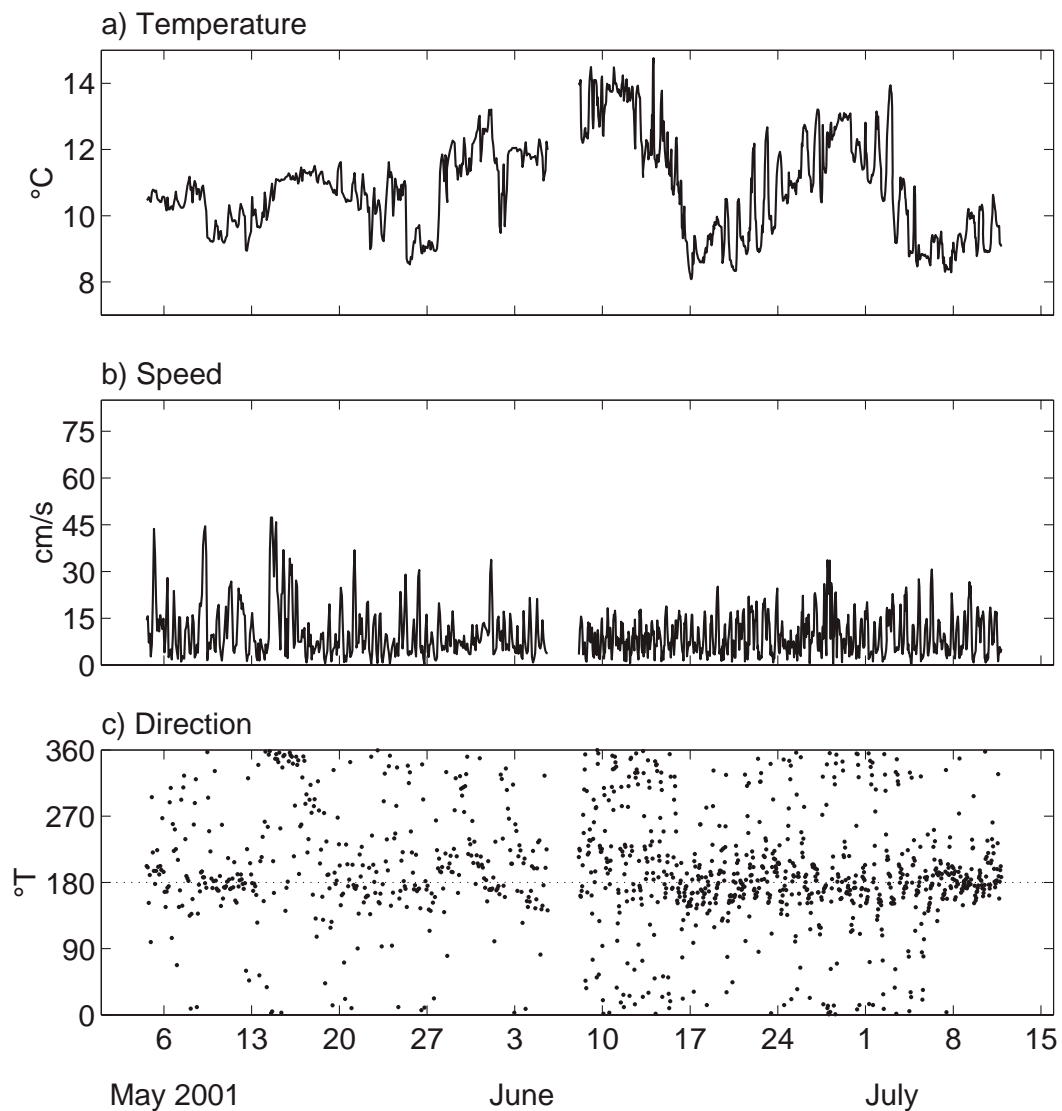


Figure 67. Time series of temperature, speed, and direction from the data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 244, at Site MIA. $^{\circ}\text{T}$ —degrees from true north.

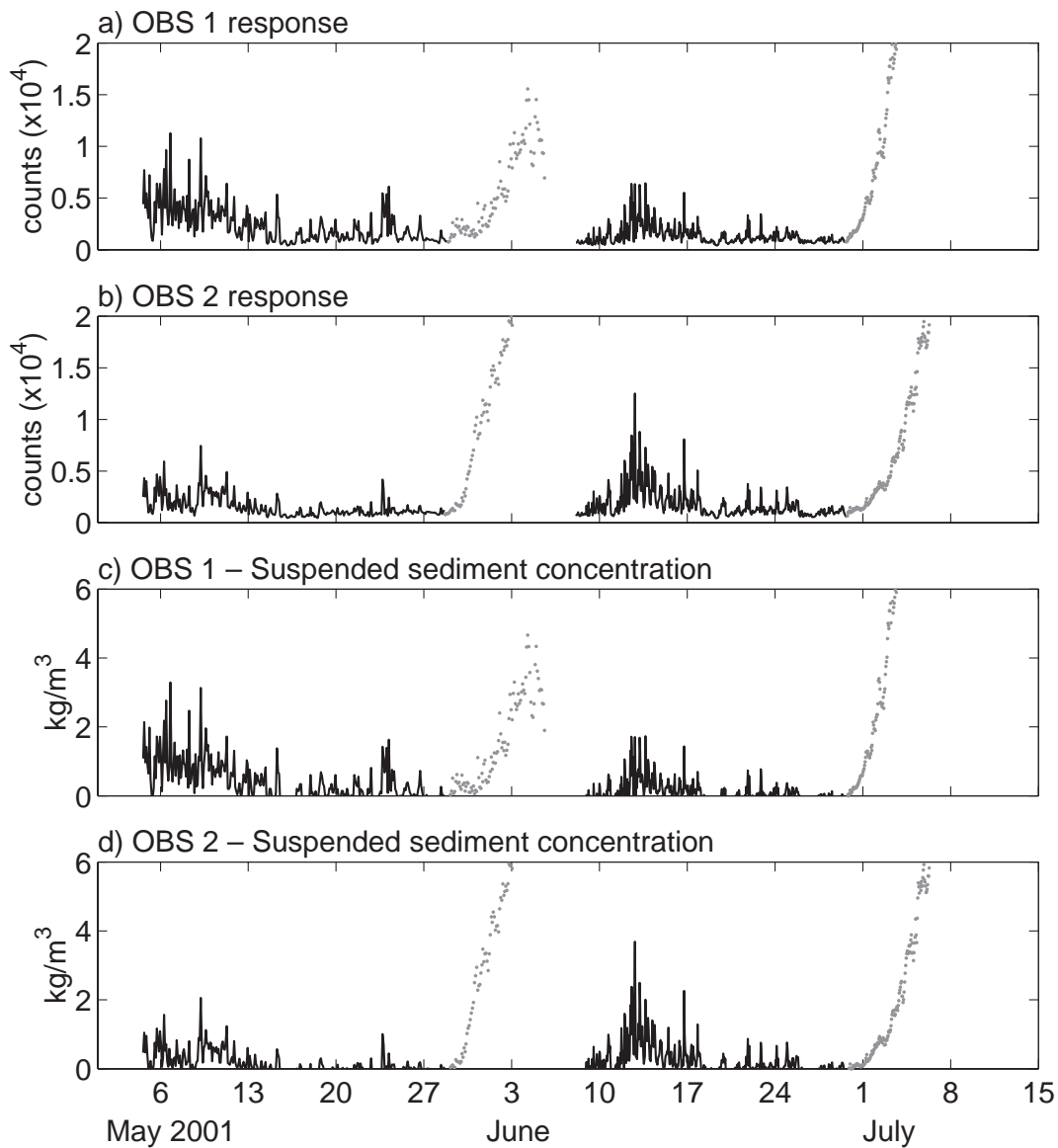


Figure 68. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Field velocimeter (ADVF), serial number 244, at Site MIA. The entire OBS record is displayed; data influenced by biofouling is in grey.

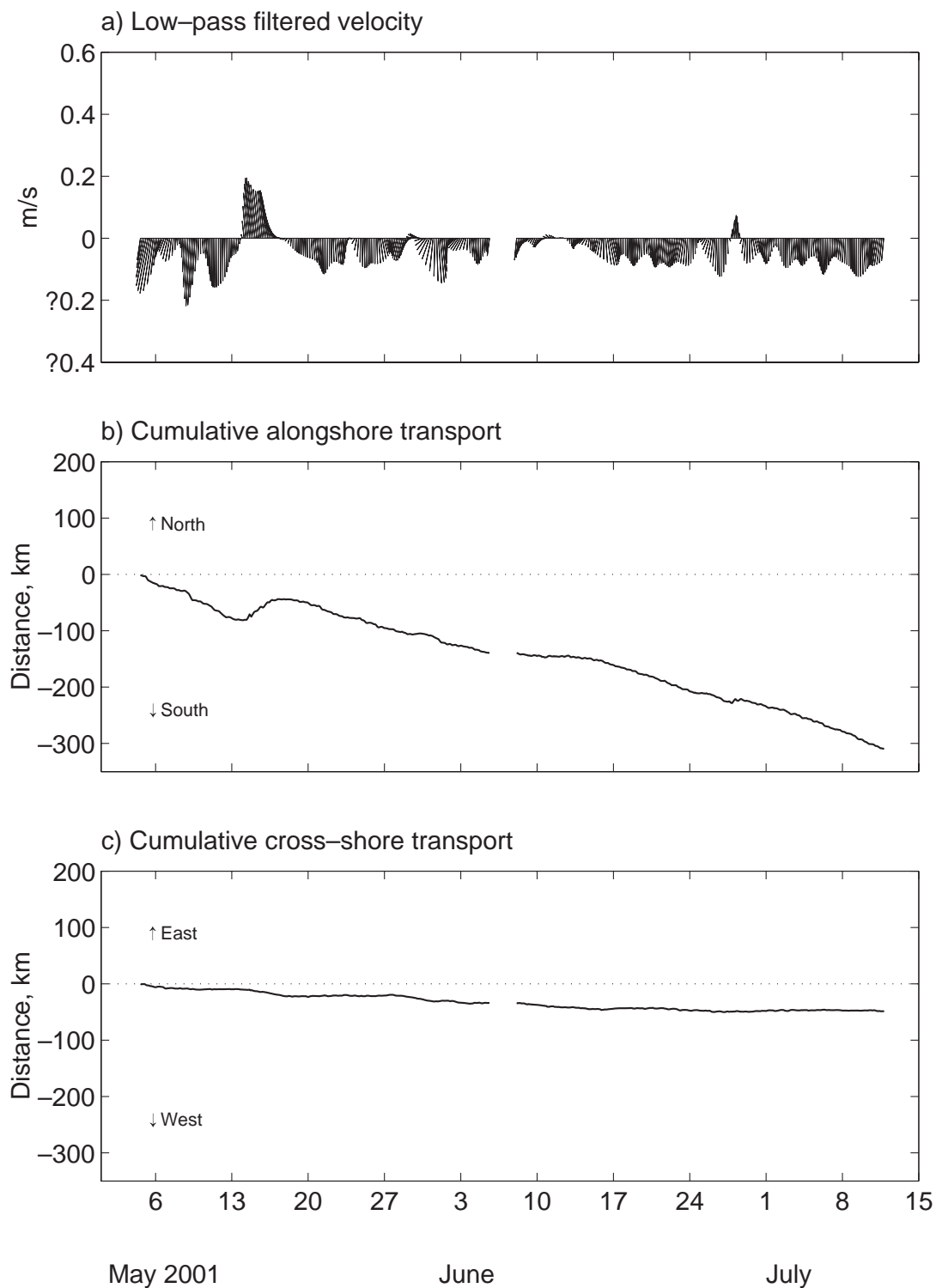


Figure 69. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Field velocimeter (ADVF), serial number 244, data for Site MIA.

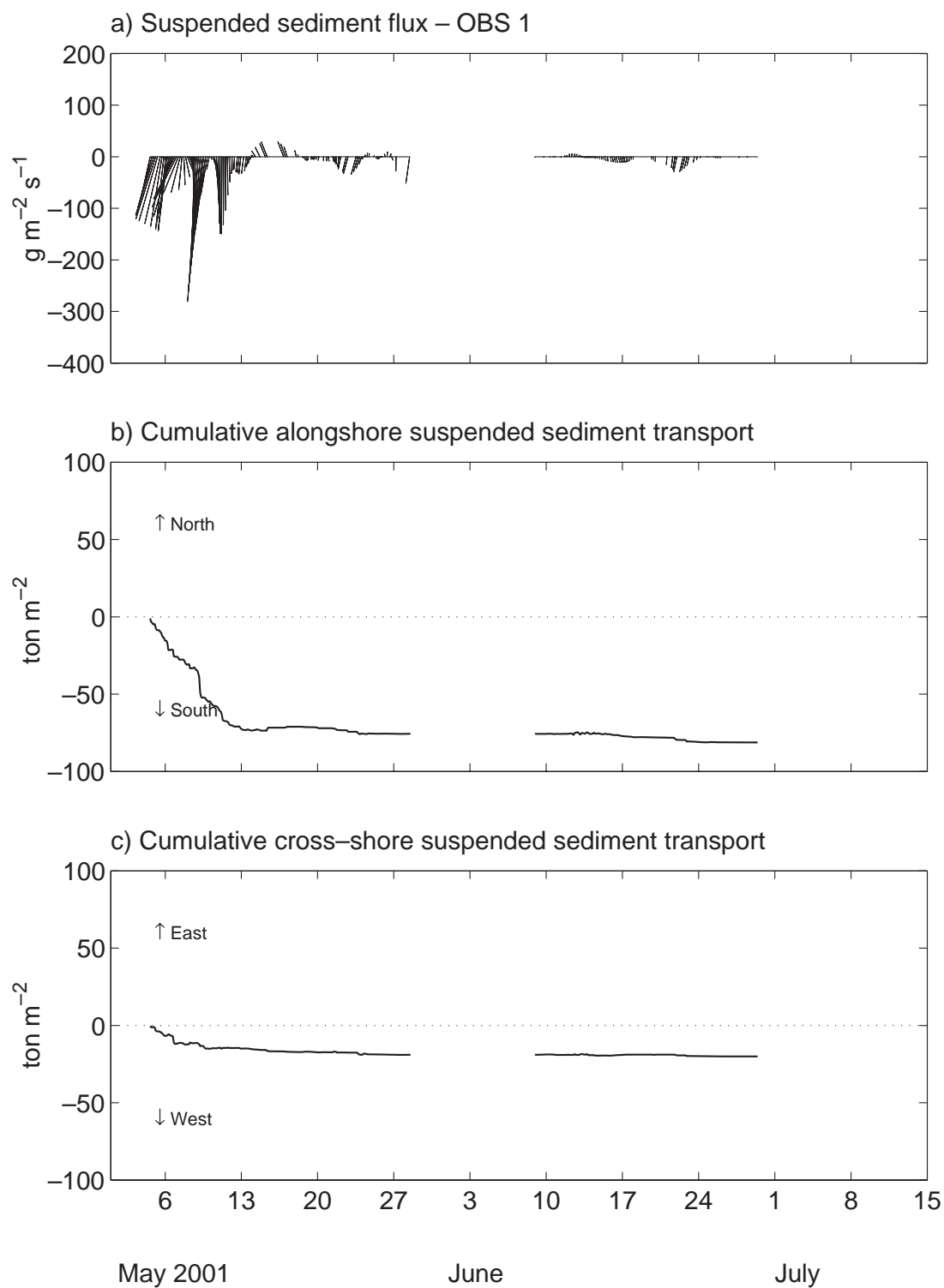


Figure 70. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Field velocimeter (ADVF), serial number 244, data for Site MIA. Times series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

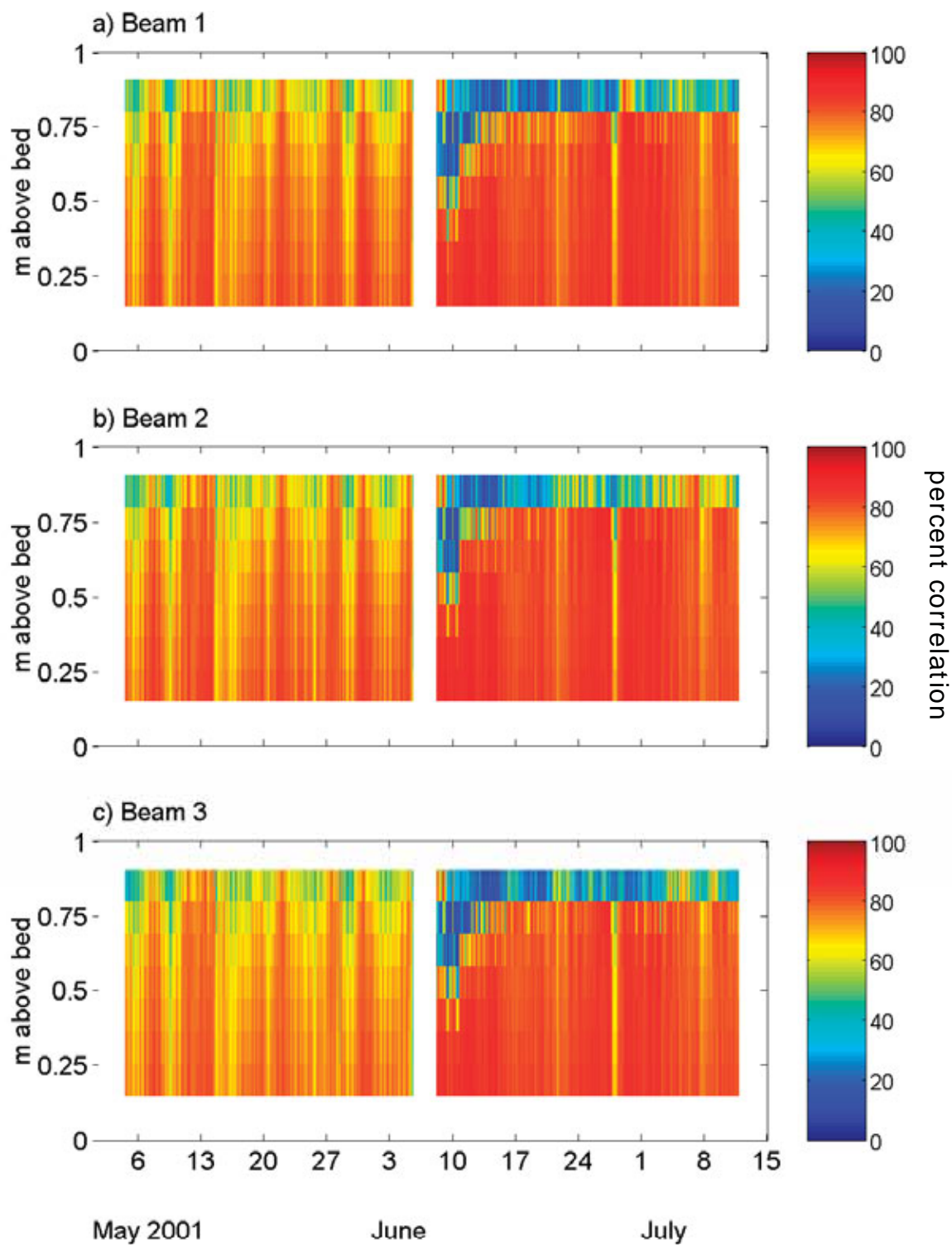


Figure 71. Time series of burst-averaged correlation for each pulse-coherent acoustic Doppler profiler (PCADP) beam from data collected at Site MIA.

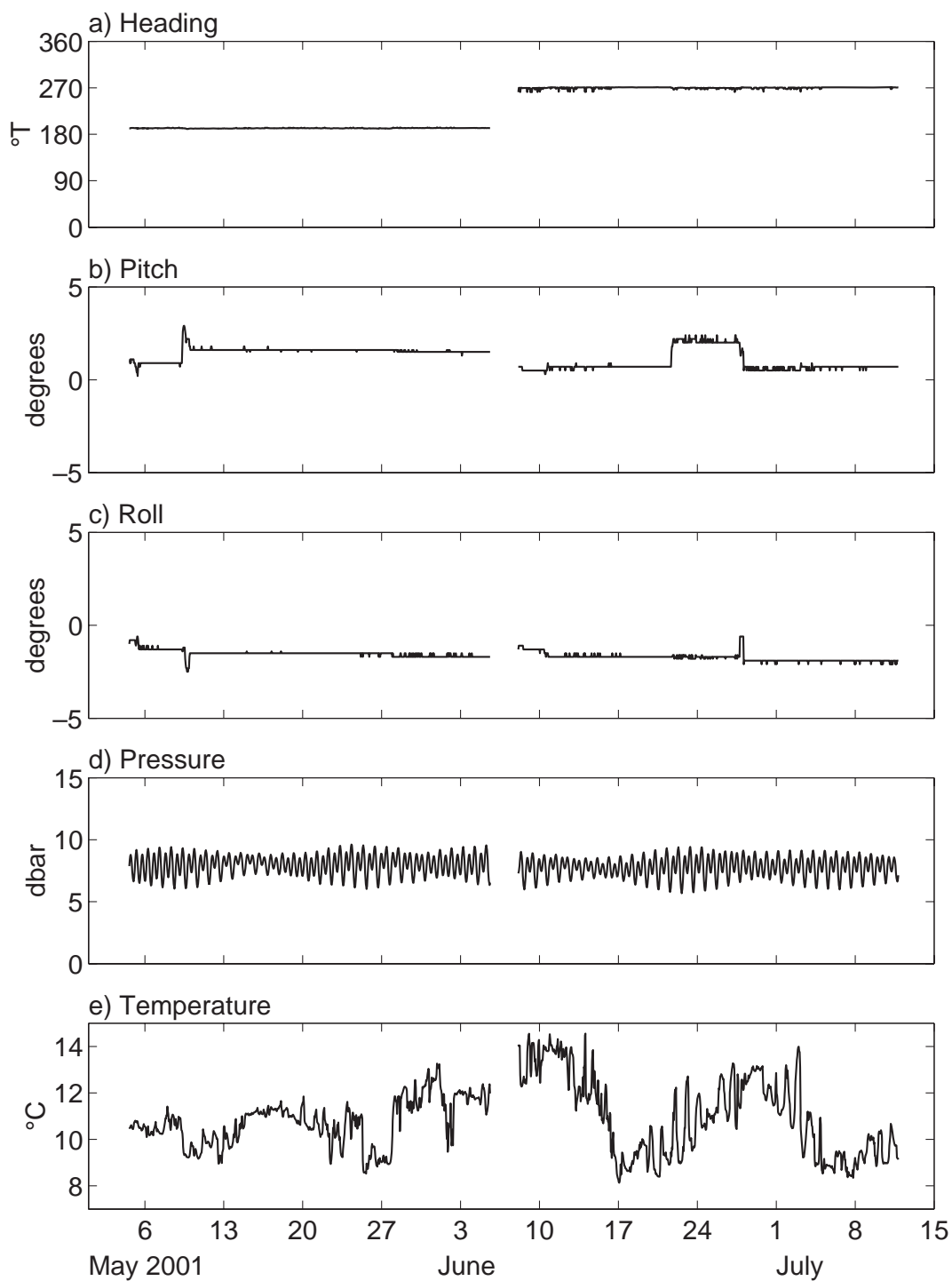


Figure 72. Time series of heading, pitch, roll, pressure, and temperature data collected by the pulse-coherent acoustic Doppler profiler (PCADP) at Site MIA. $^{\circ}\text{T}$ —degrees from true north.

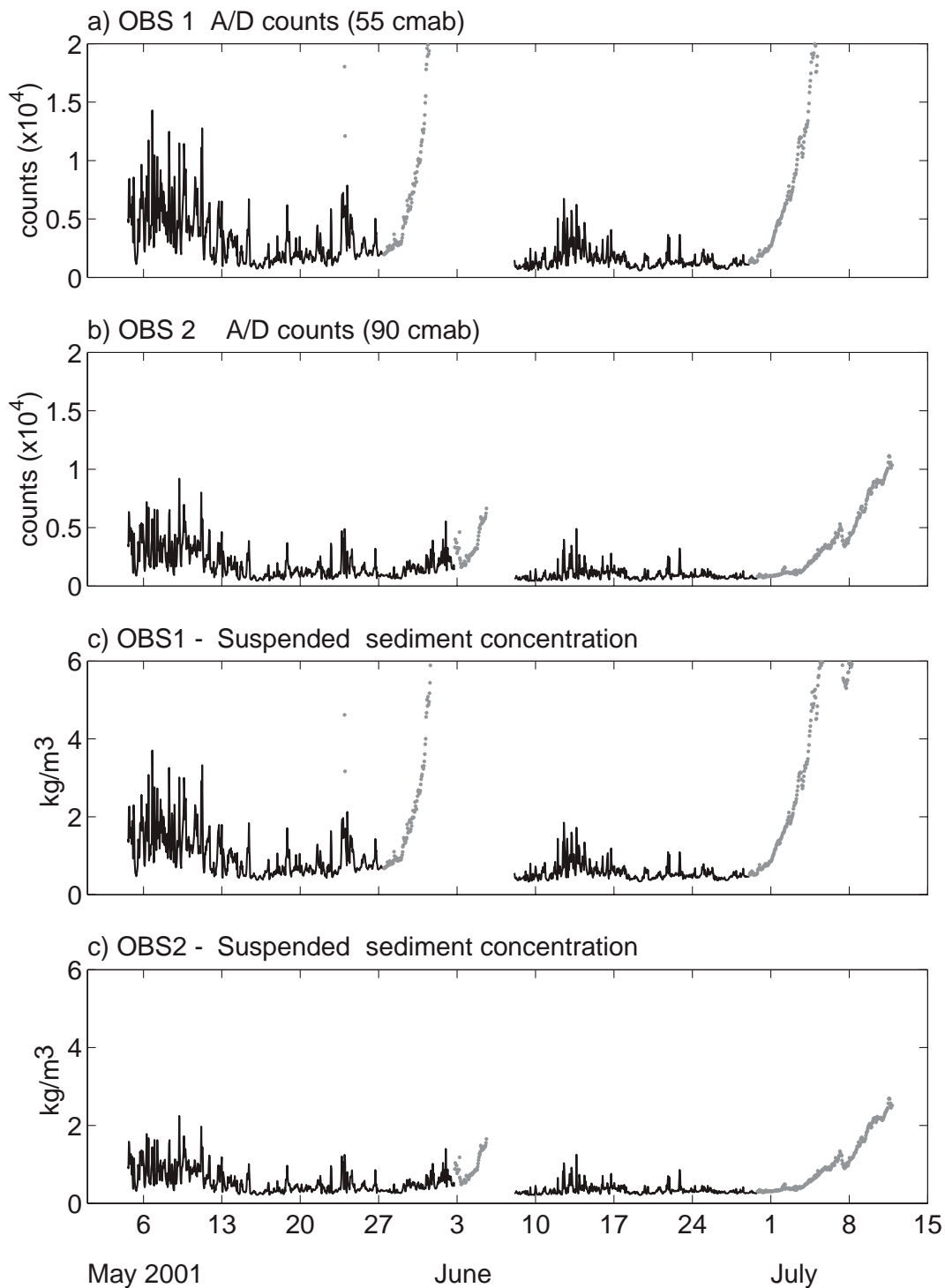


Figure 73. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the pulse-coherent acoustic Doppler profiler (PCADP) at Site MIA. The entire optical backscatter (OBS) record is displayed; data influenced by biofouling is in grey.

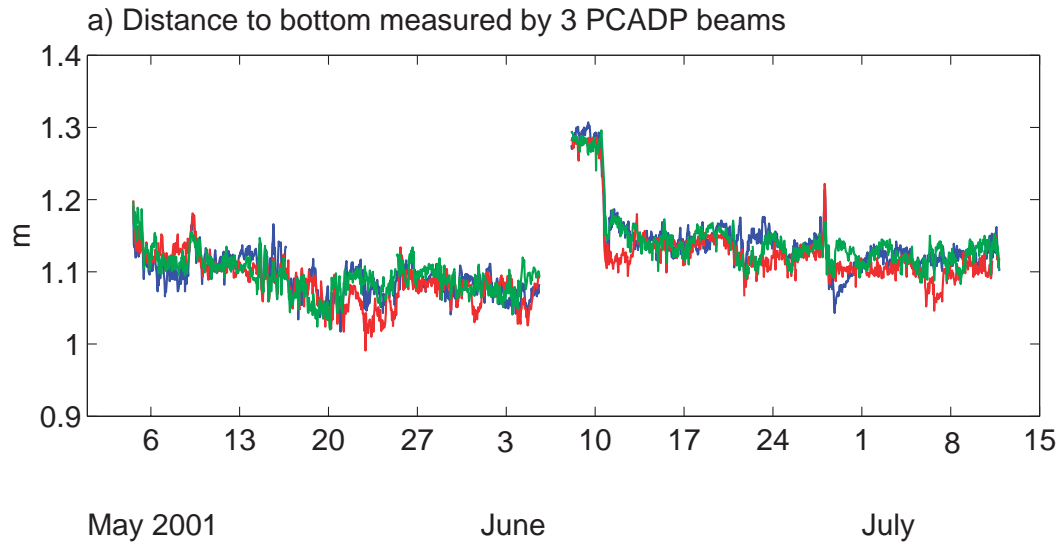


Figure 74. Time series of distance to the bottom as reported by each beam of the pulse-coherent acoustic Doppler profiler (PCADP) from data collected at Site MIA: blue is beam 1, red is beam 2, and green is beam 3. Distance to bottom is from PCADP transducer.

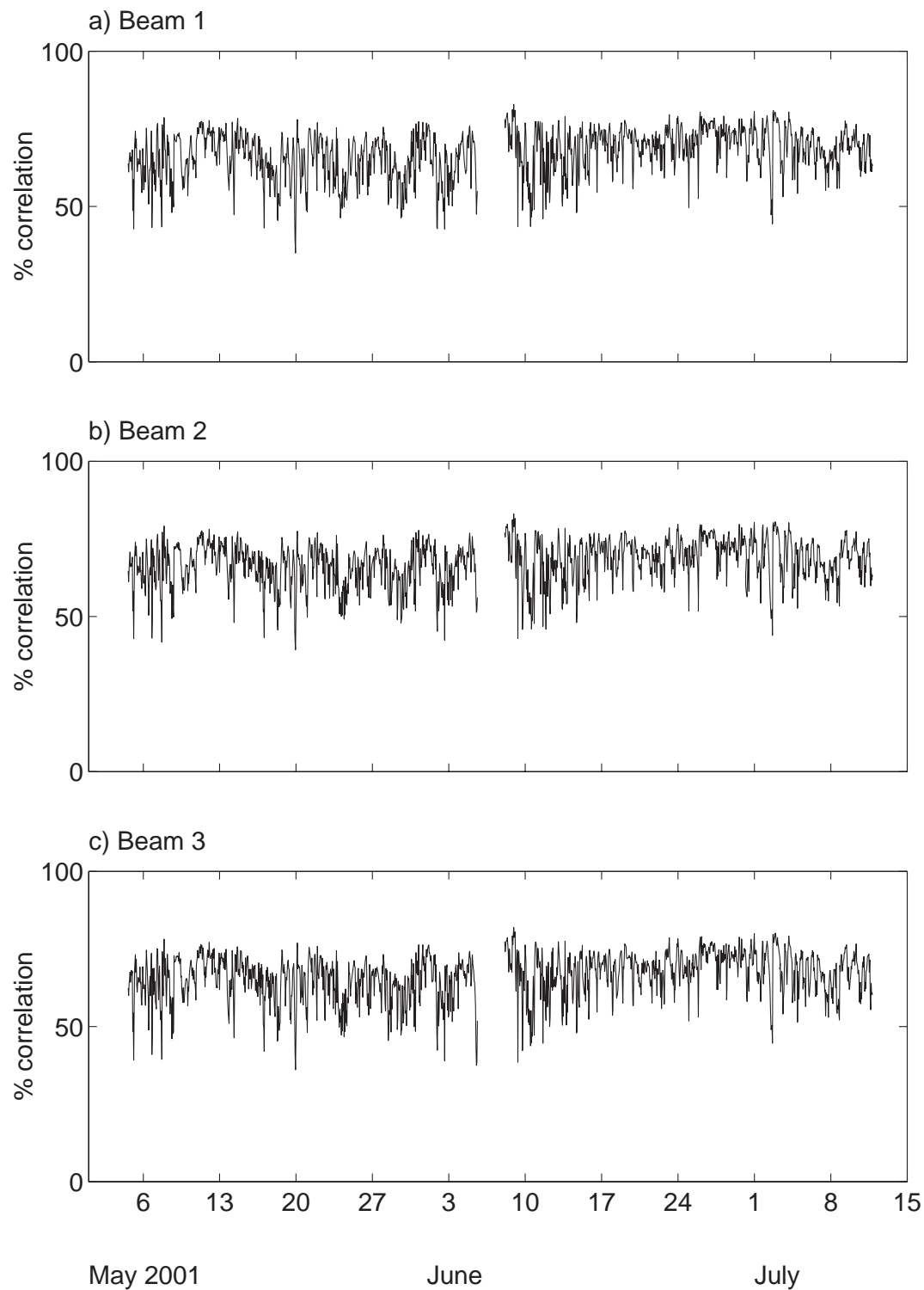


Figure 75. Time series of the correlation of the pulse-coherent acoustic Doppler profiler (PCADP) resolution velocity, which is only measured in one cell, for each beam from data collected by the PCADP at Site MIA. Cell 2 is the closest cell to the resolution cell.

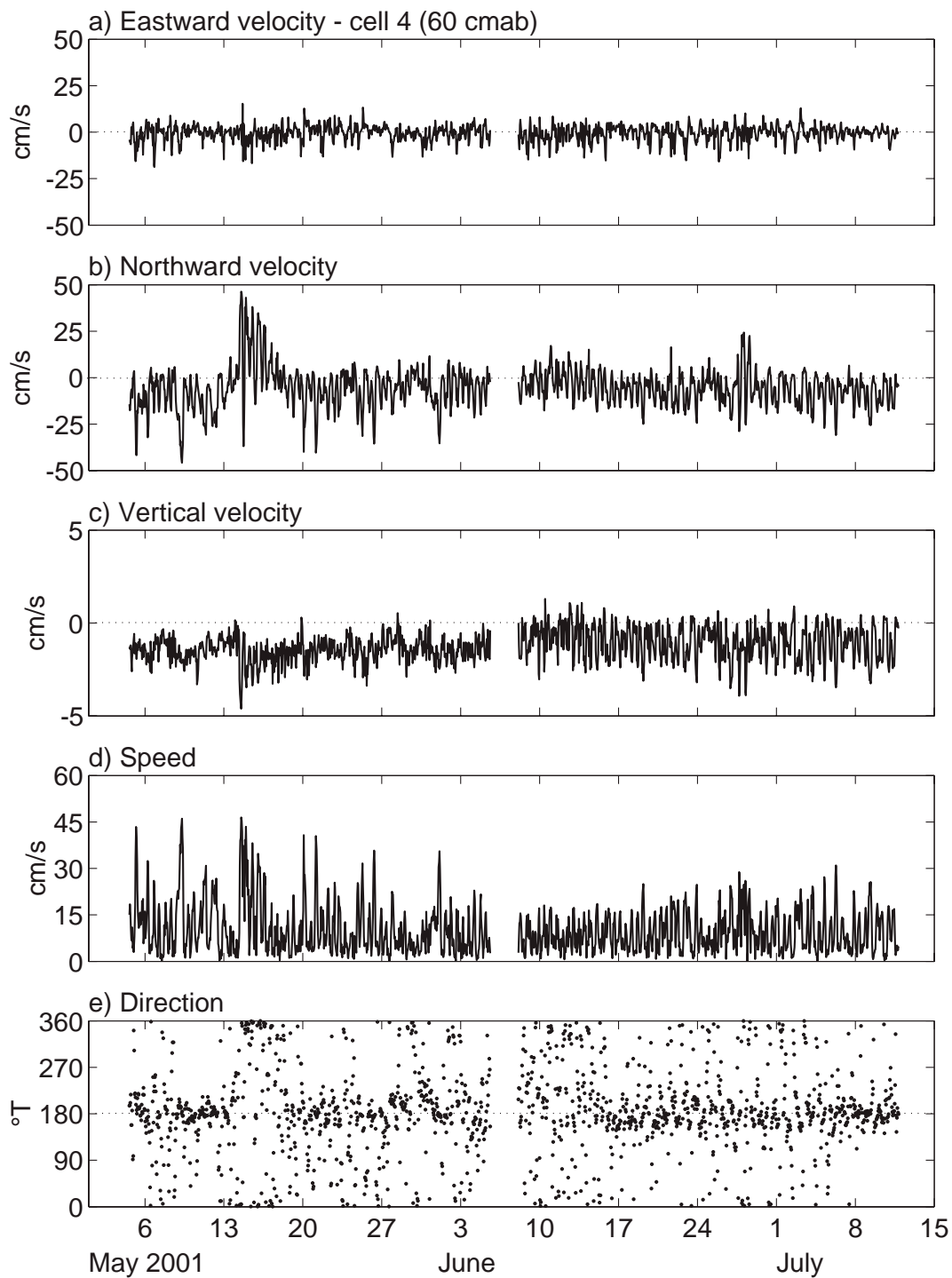


Figure 76. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 4 (60 cmab—centimeters above bed) from data collected by the pulse-coherent acoustic Doppler profiler (PCADP) at Site MIA. °T—degrees from true north.

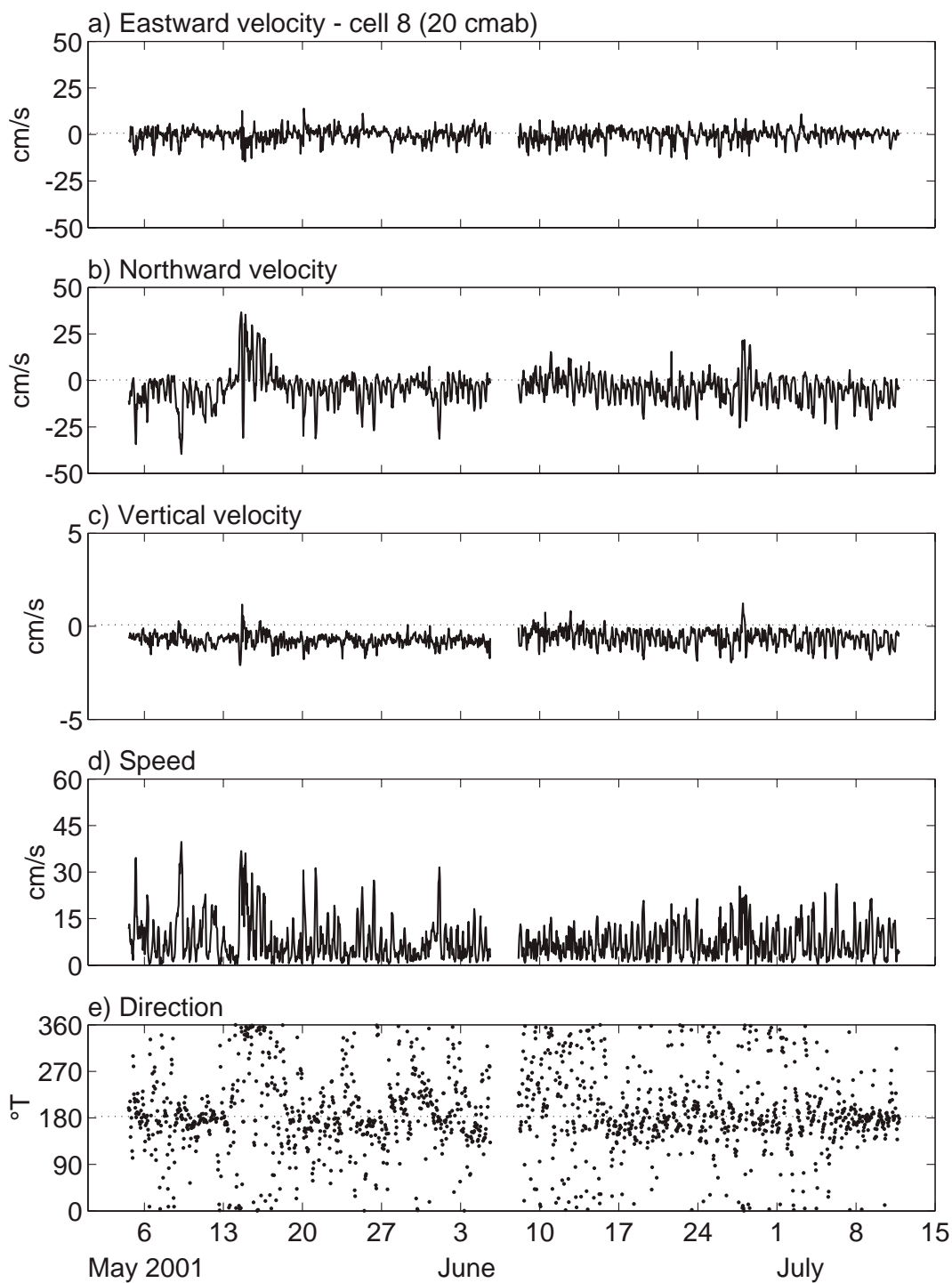


Figure 77. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 8 (20 cmab—centimeters above bed) from data collected by the pulse-coherent acoustic Doppler profiler (PCADP) at Site MIA. °T—degrees from true north.

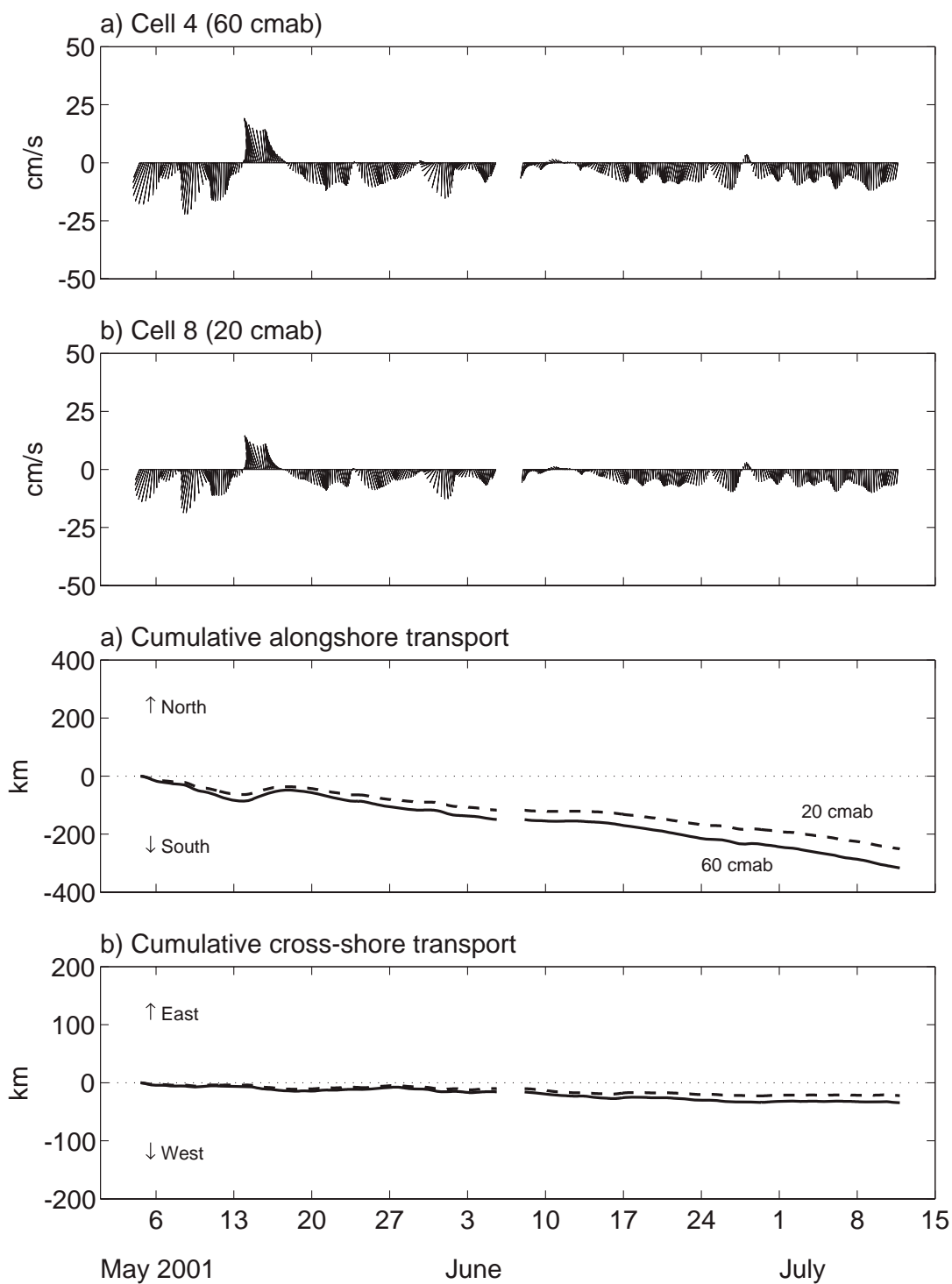


Figure 78. Time series of low-pass filtered velocity, and cumulative alongshore and cross-shore transport for two pulse-coherent acoustic Doppler profiler (PCADP) cells at Site MIA: -- is 20 cmab (centimeters above bed), and solid line is 60 cmab.

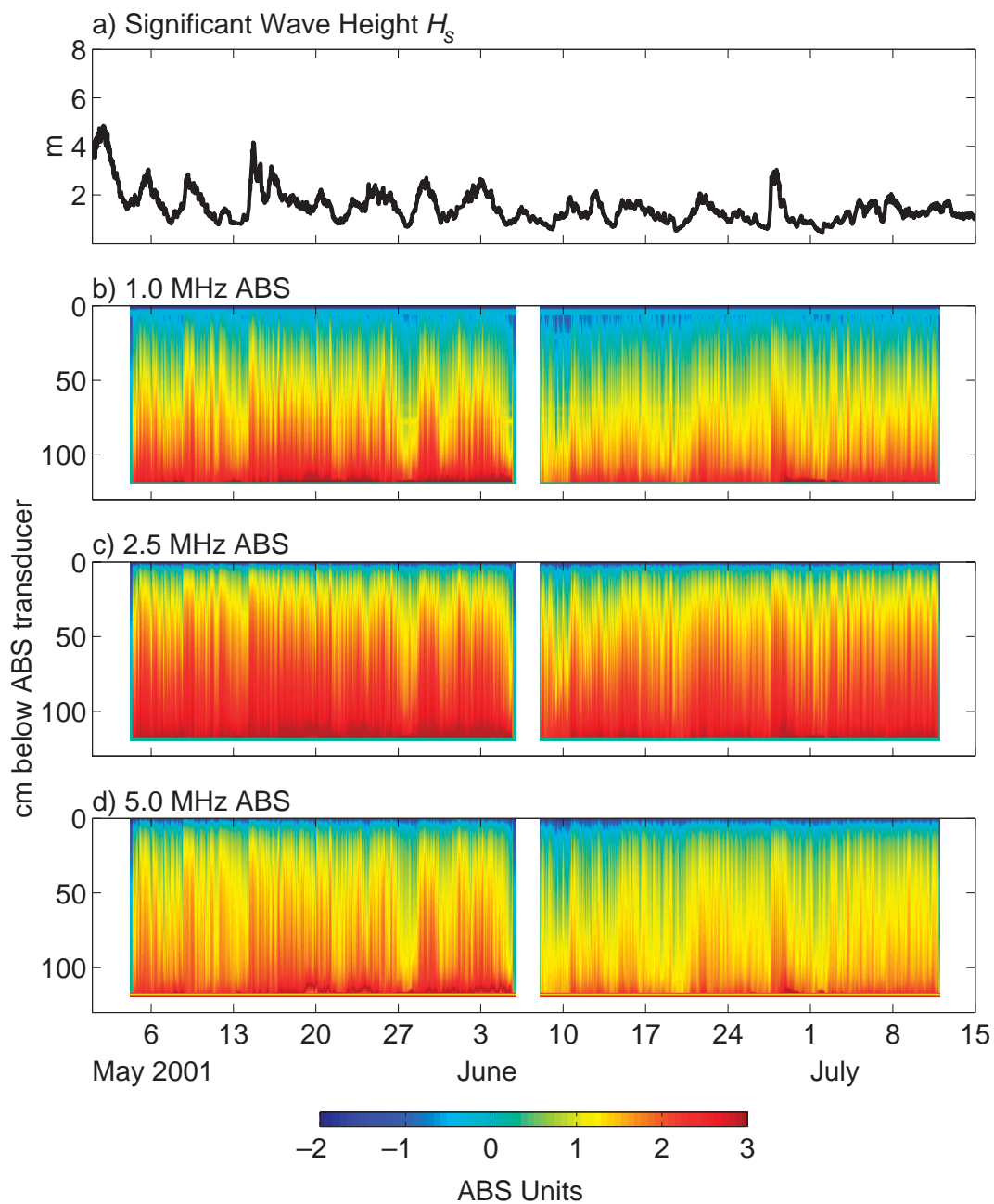


Figure 79. Time series of significant wave height as reported by the Coastal Data Information Program (CDIP) wave buoy, and the uncalibrated response of each frequency of acoustic backscatter system (ABS) deployed at Site MIA.

3.3.5 Site MIB

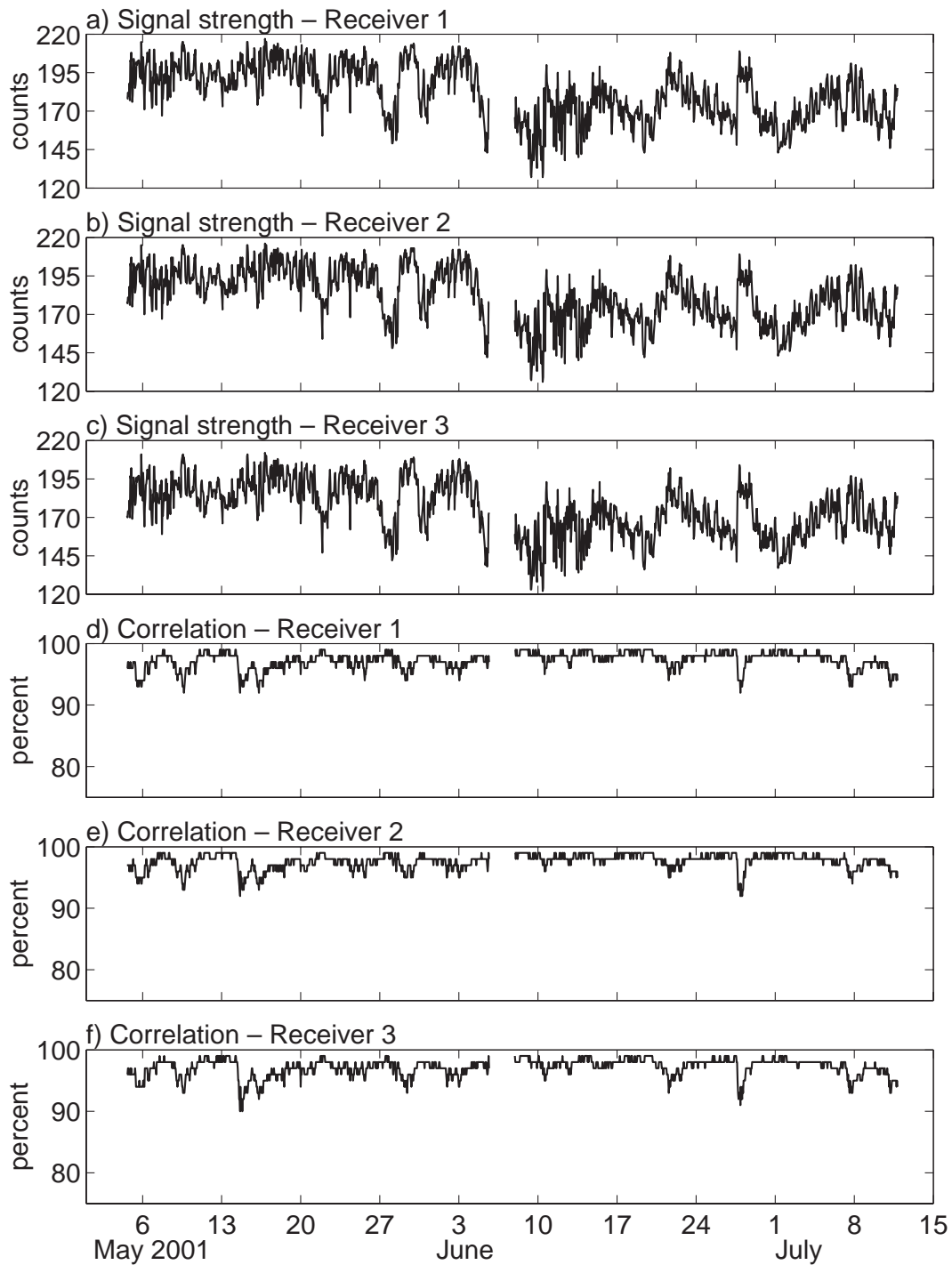


Figure 80. Time series of signal strength and signal correlation for each acoustic Doppler Ocean velocimeter (ADV0) receiver at Site MIB.

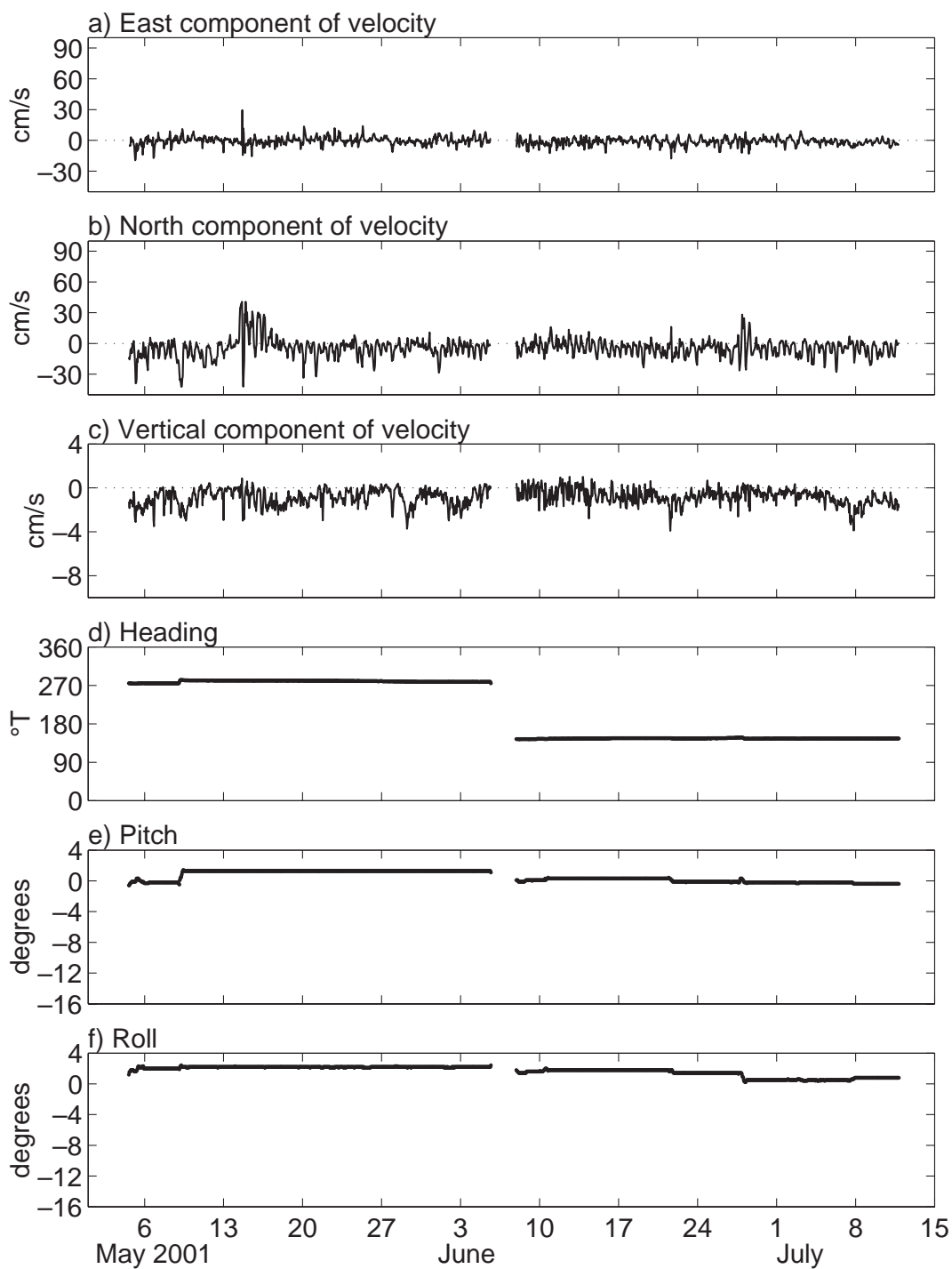


Figure 81. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MIB. °T—degrees from true north.

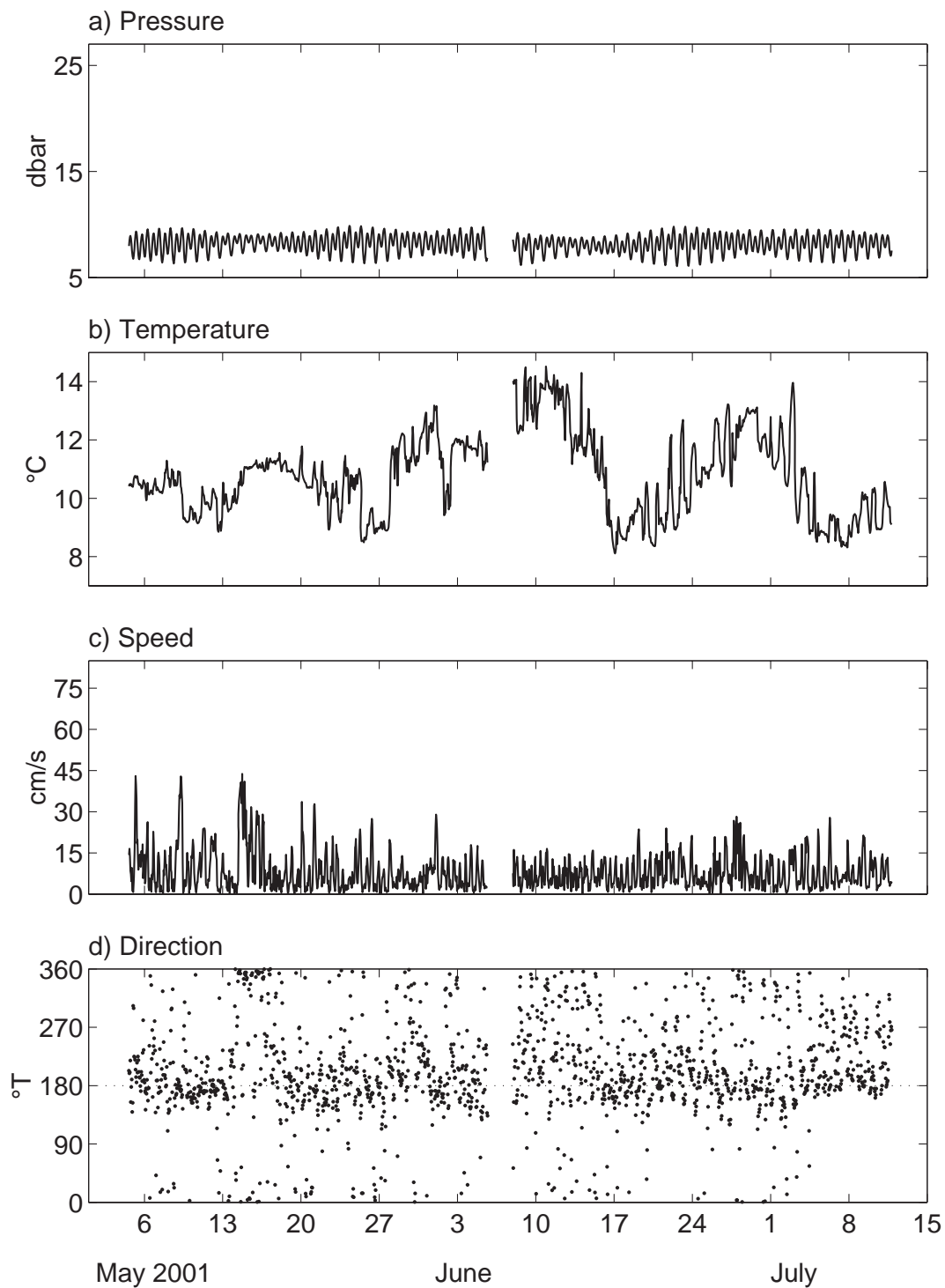


Figure 82. Time series of pressure, temperature, speed, and direction from the data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MIB. °T—degrees from true north.

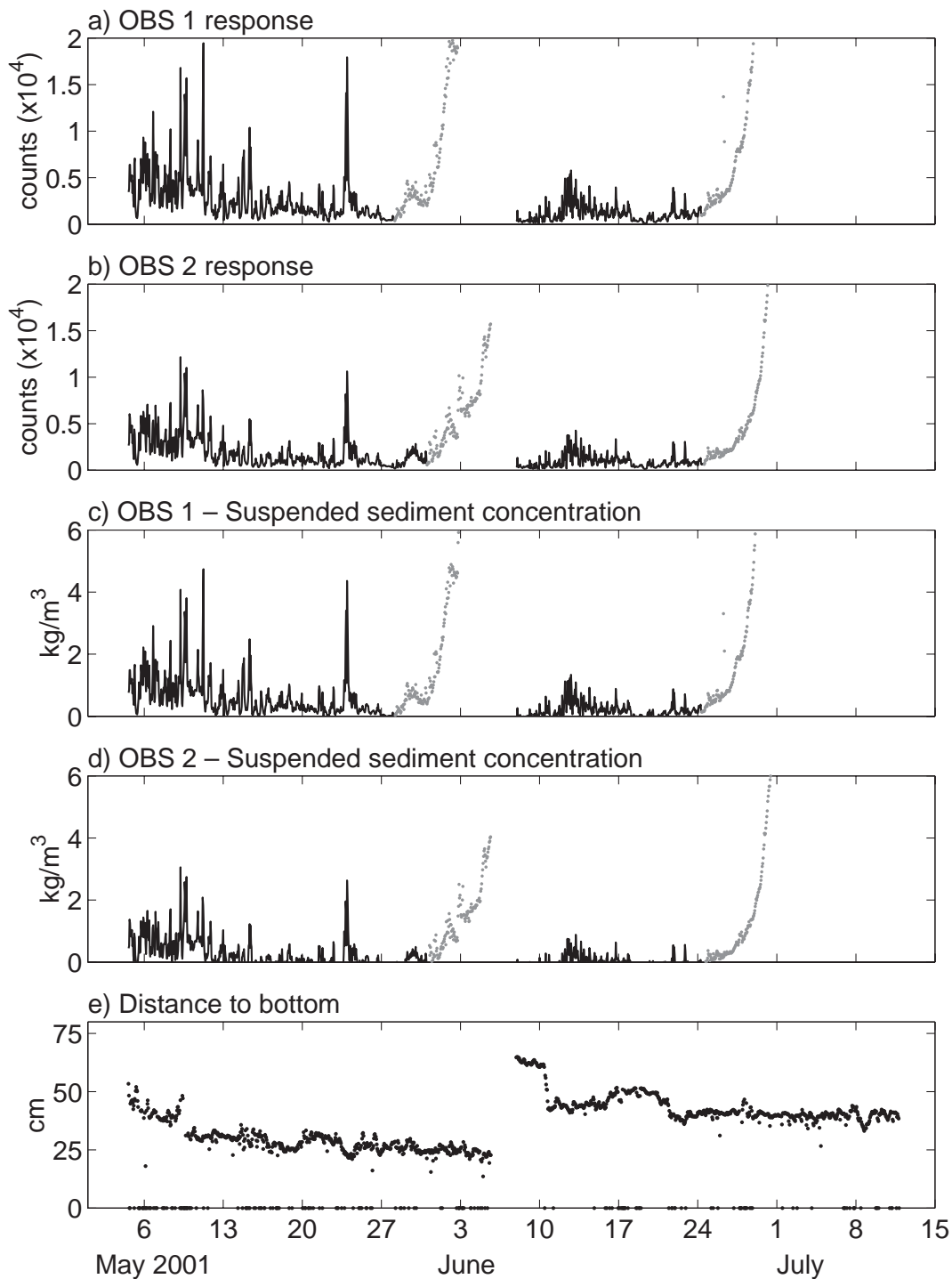


Figure 83. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site MIB. The entire OBS record is displayed; data influenced by biofouling is in grey. Distance to bottom is distance from the center of the ADVO sampling volume.

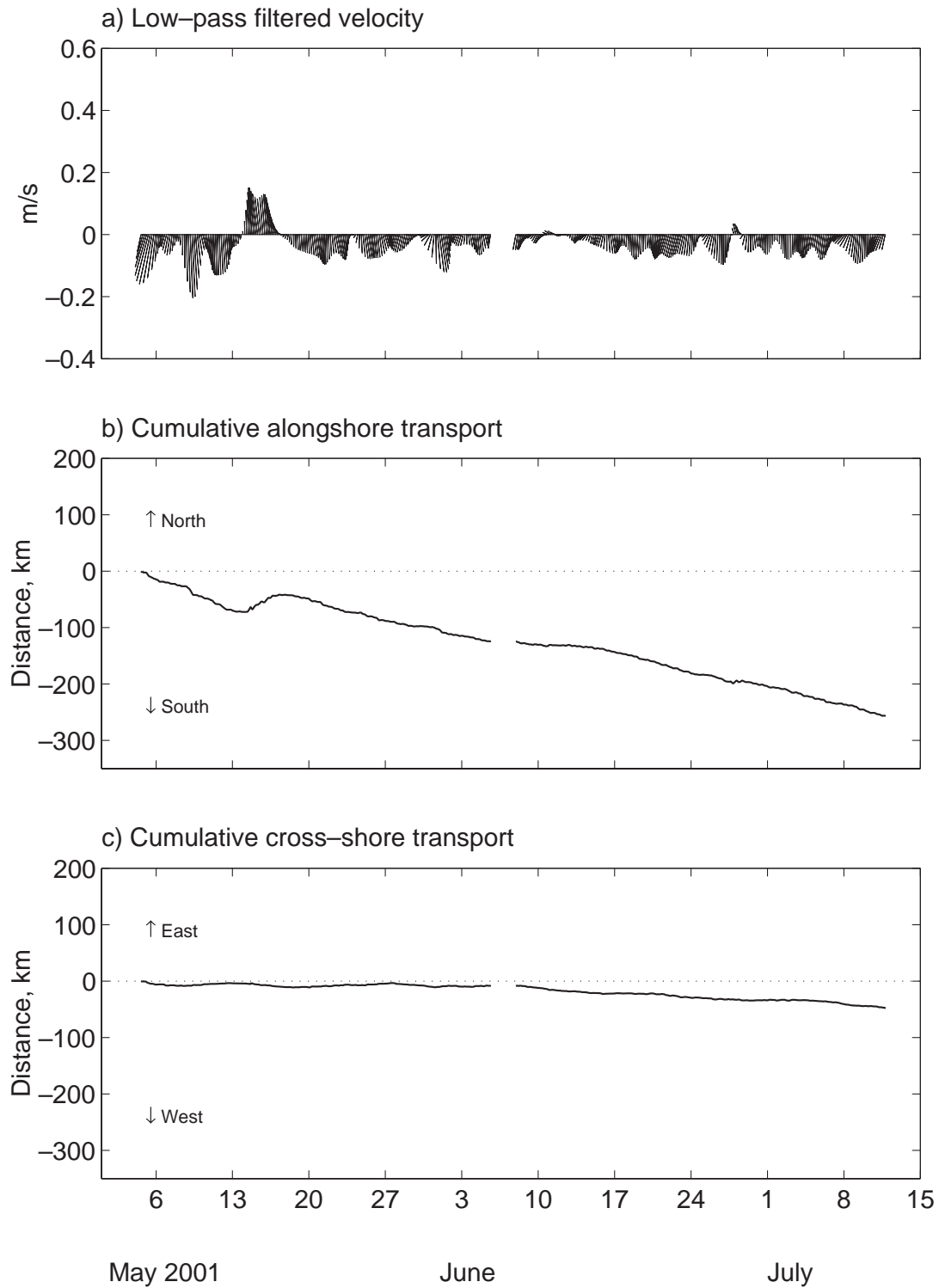


Figure 84. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site MIB.

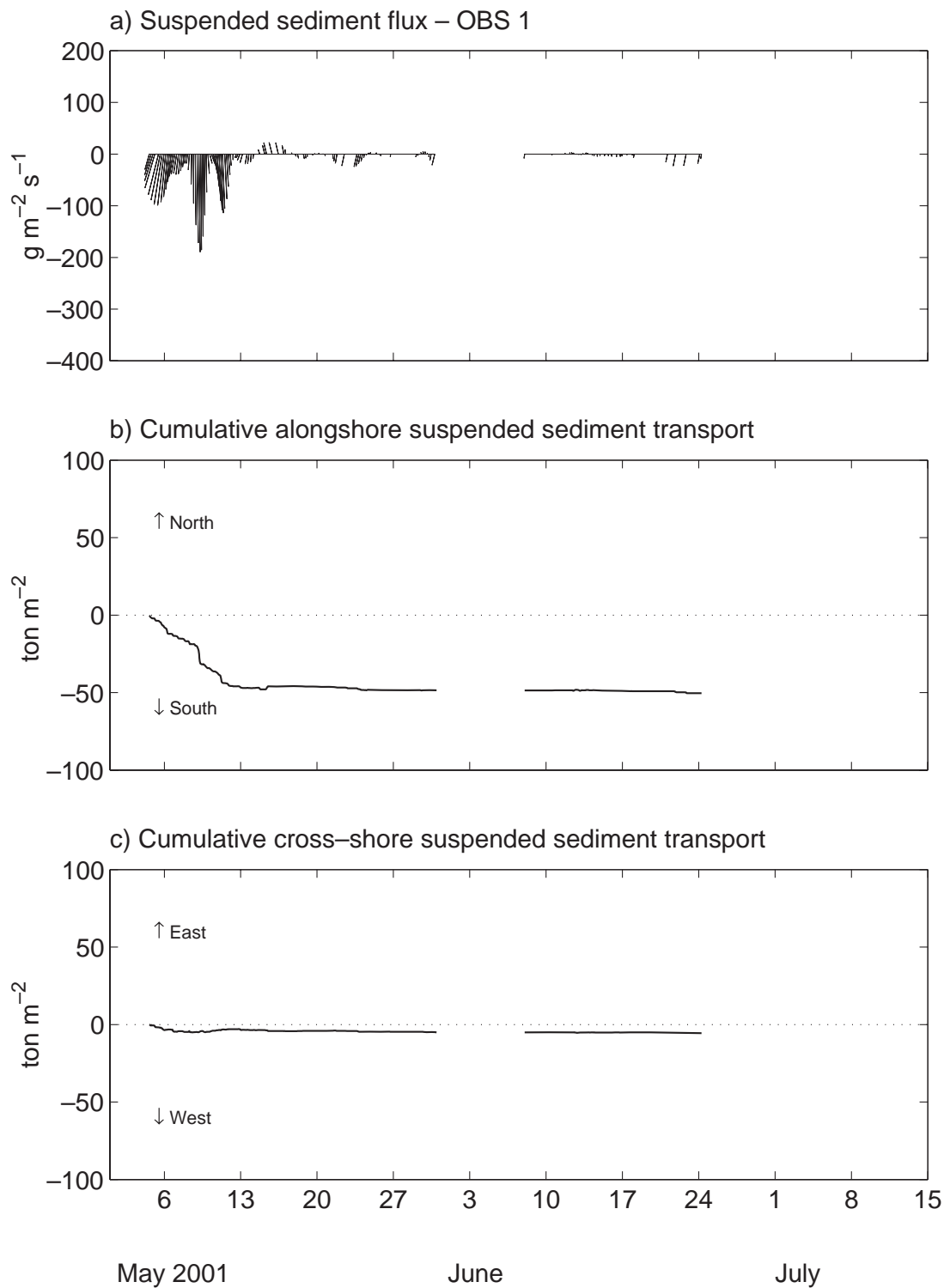


Figure 85. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Ocean velocimeter (ADV0) data for Site MIB. Time series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

3.3.6 Site SD

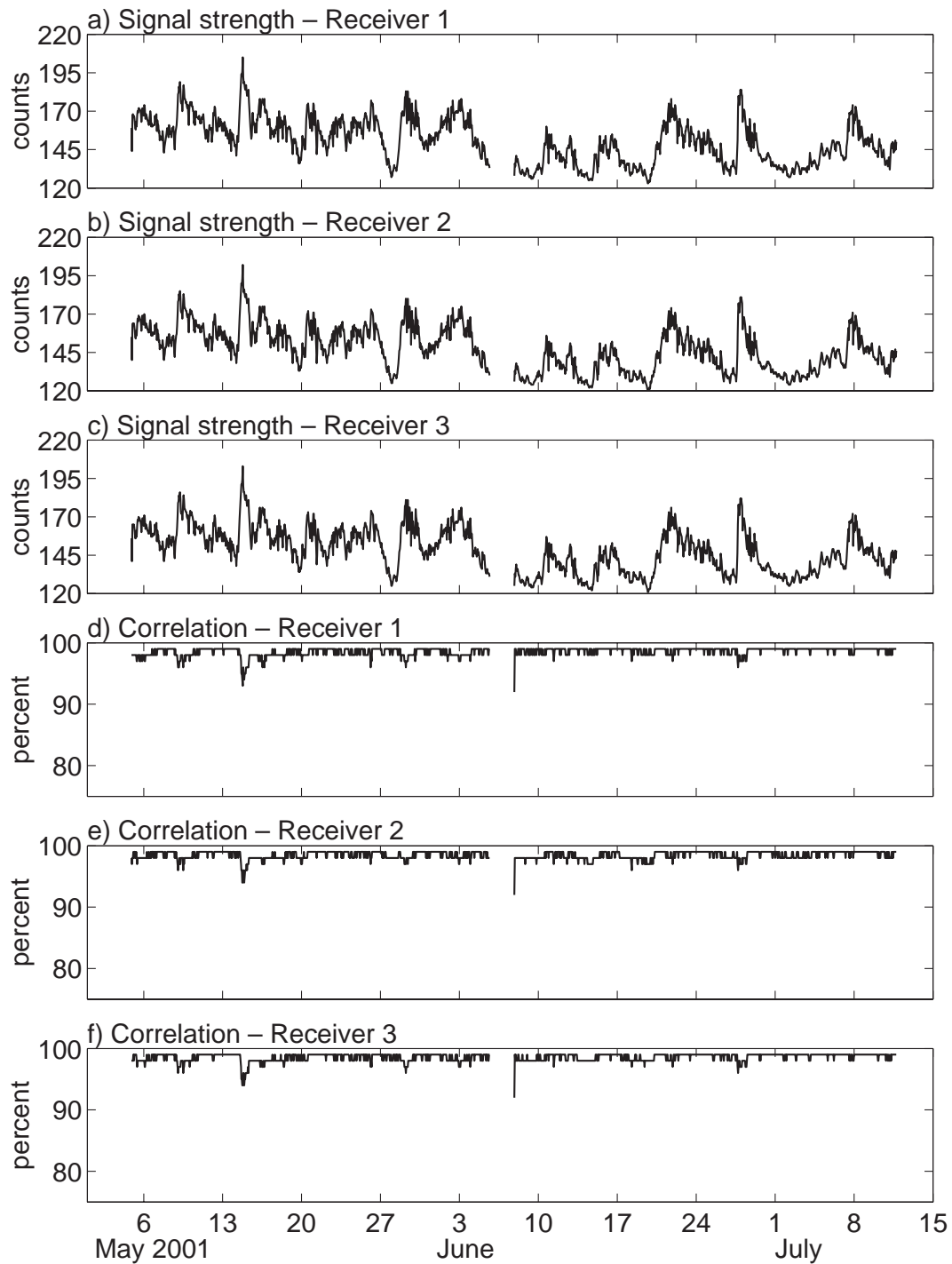


Figure 86. Time series of signal strength and signal correlation for each acoustic Doppler Ocean velocimeter (ADV0) receiver at Site SD.

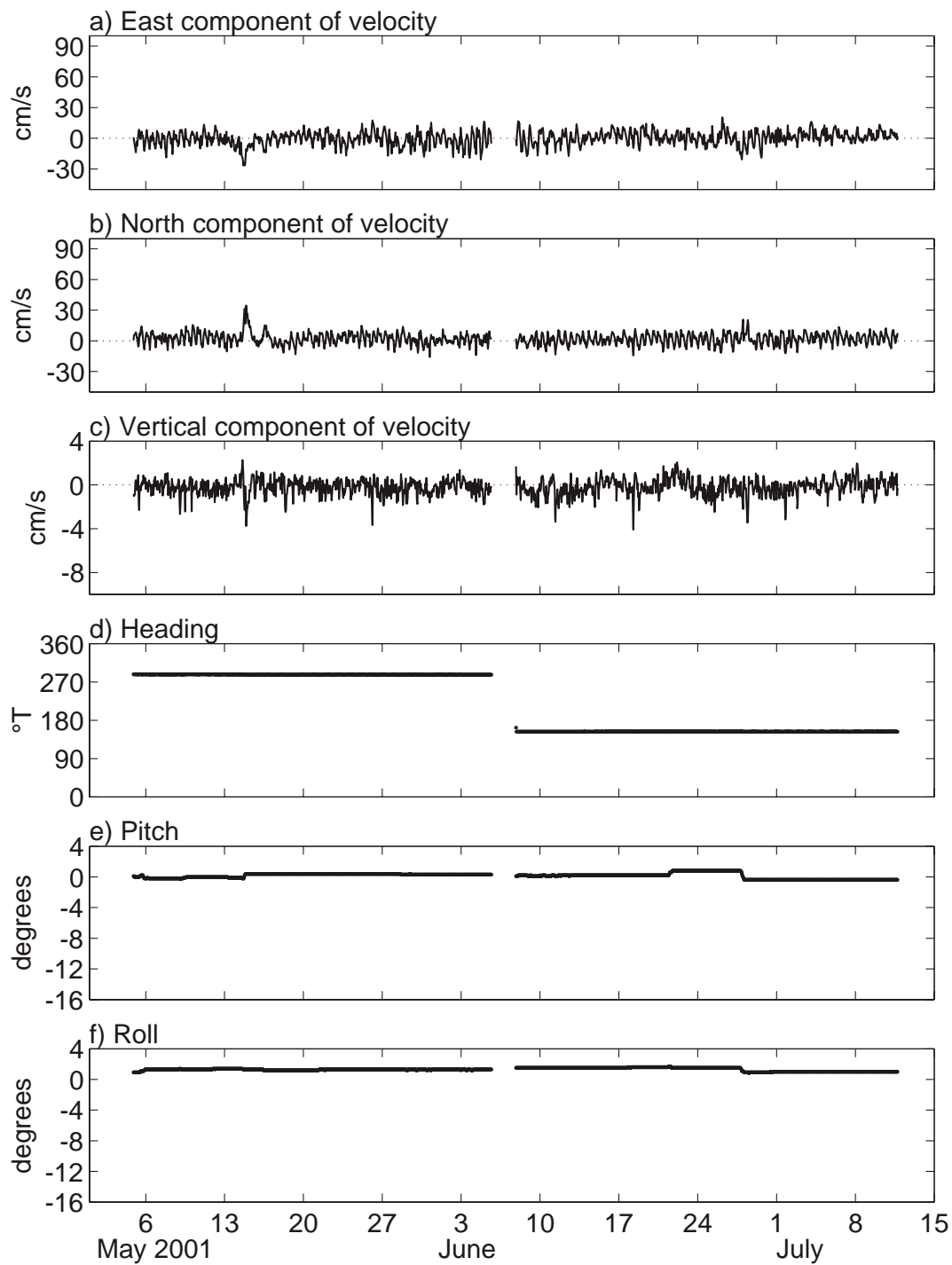


Figure 87. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, heading, pitch, and roll from data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site SD. °T—degrees from true north.

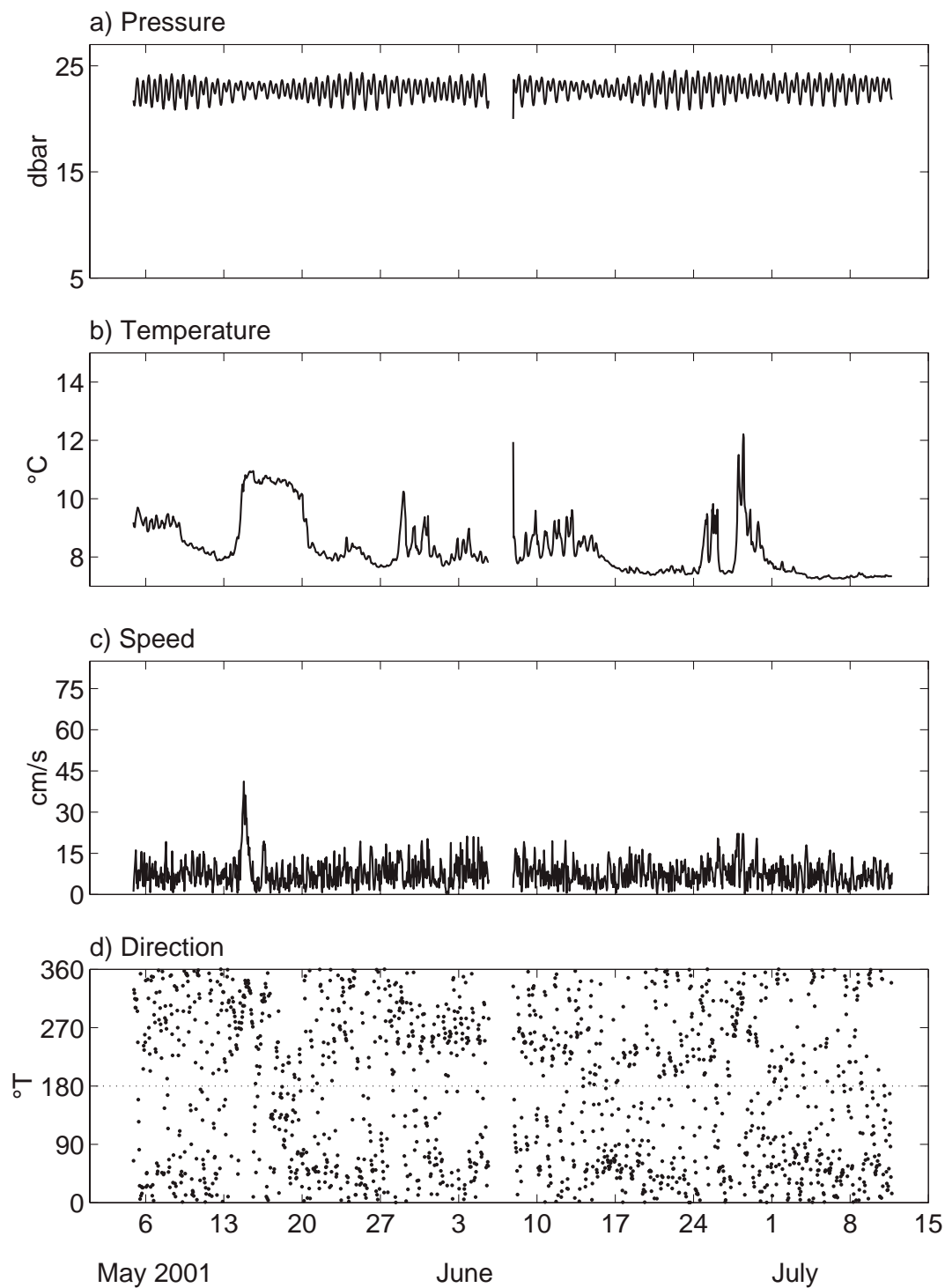


Figure 88. Time series of pressure, temperature, speed, and direction from the data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site SD. °T—degrees from true north.

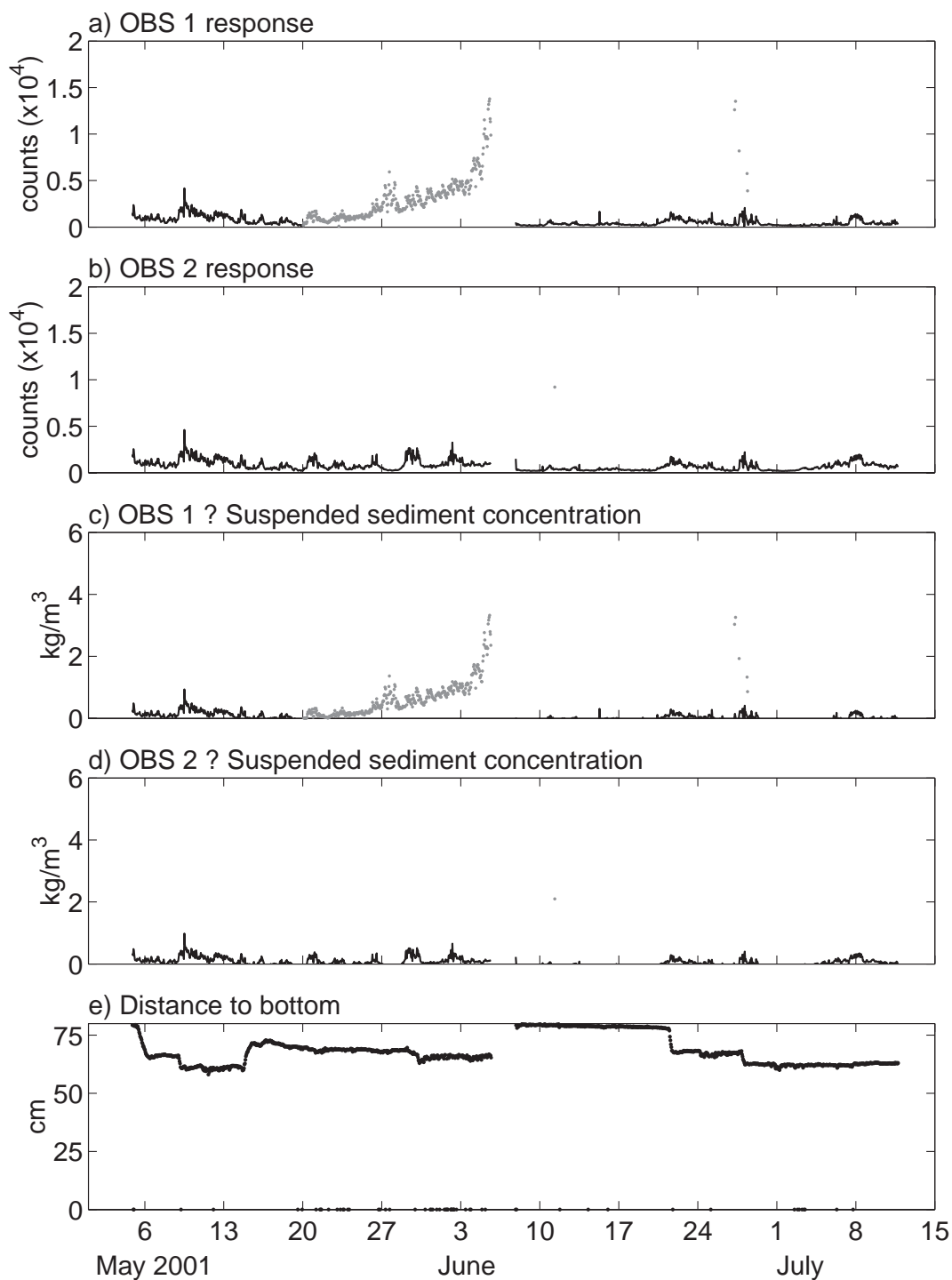


Figure 89. Time series of raw optical backscatter (OBS) data, calibrated OBS data, and distance to bottom data collected by the acoustic Doppler Ocean velocimeter (ADVO) at Site SD. The entire OBS record is displayed; data influenced by biofouling is in grey. Distance to bottom is distance from the center of the ADVO sampling volume.

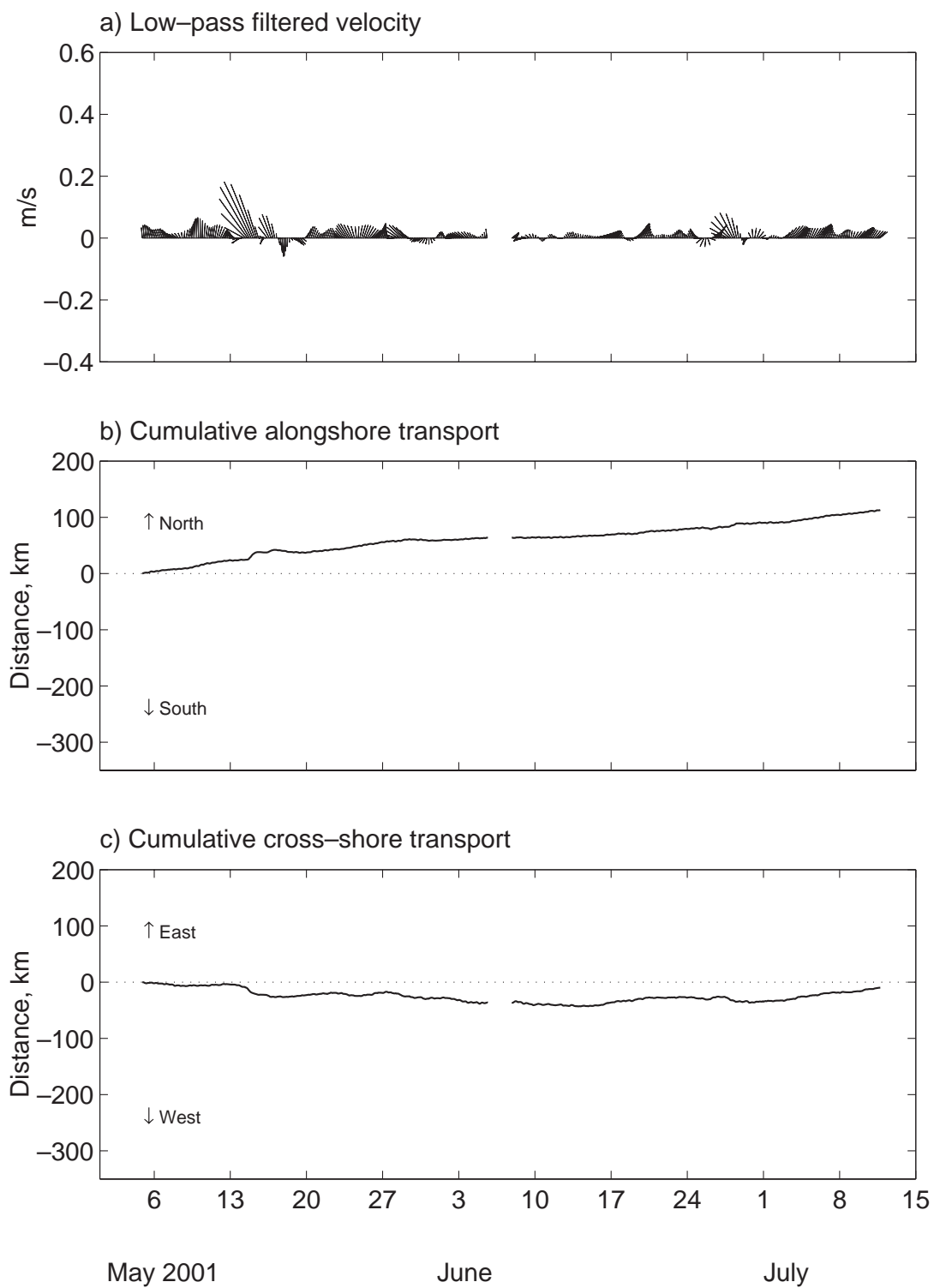


Figure 90. Time series of low-pass filtered velocity and cumulative alongshore and cross-shore transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site SD.

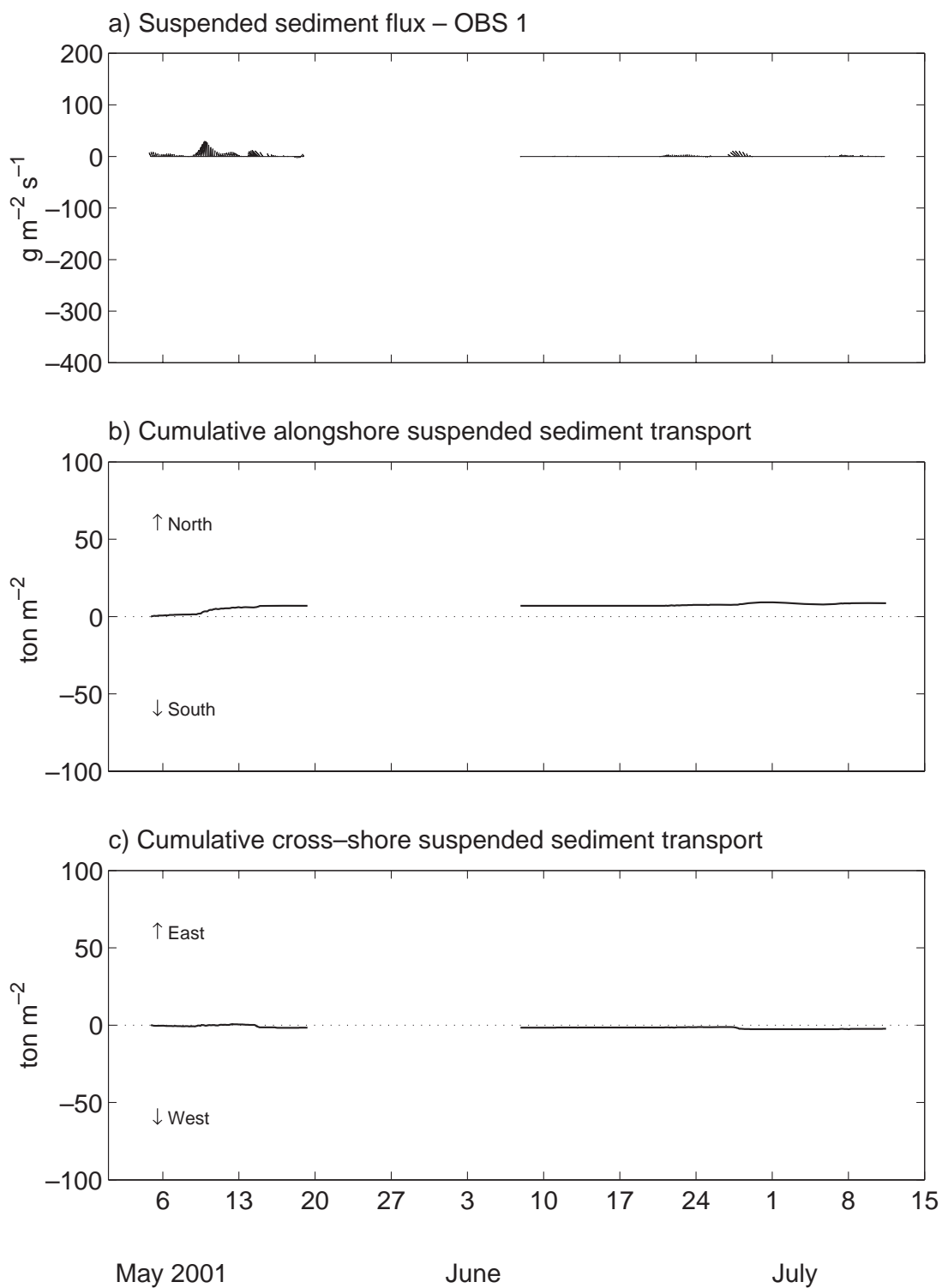


Figure 91. Time series of low-pass filtered suspended sediment flux and cumulative alongshore and cross-shore suspended sediment transport as calculated from acoustic Doppler Ocean velocimeter (ADVO) data for Site SD. Times series is constrained to period of nonbiofouled optical backscatter (OBS) data collection.

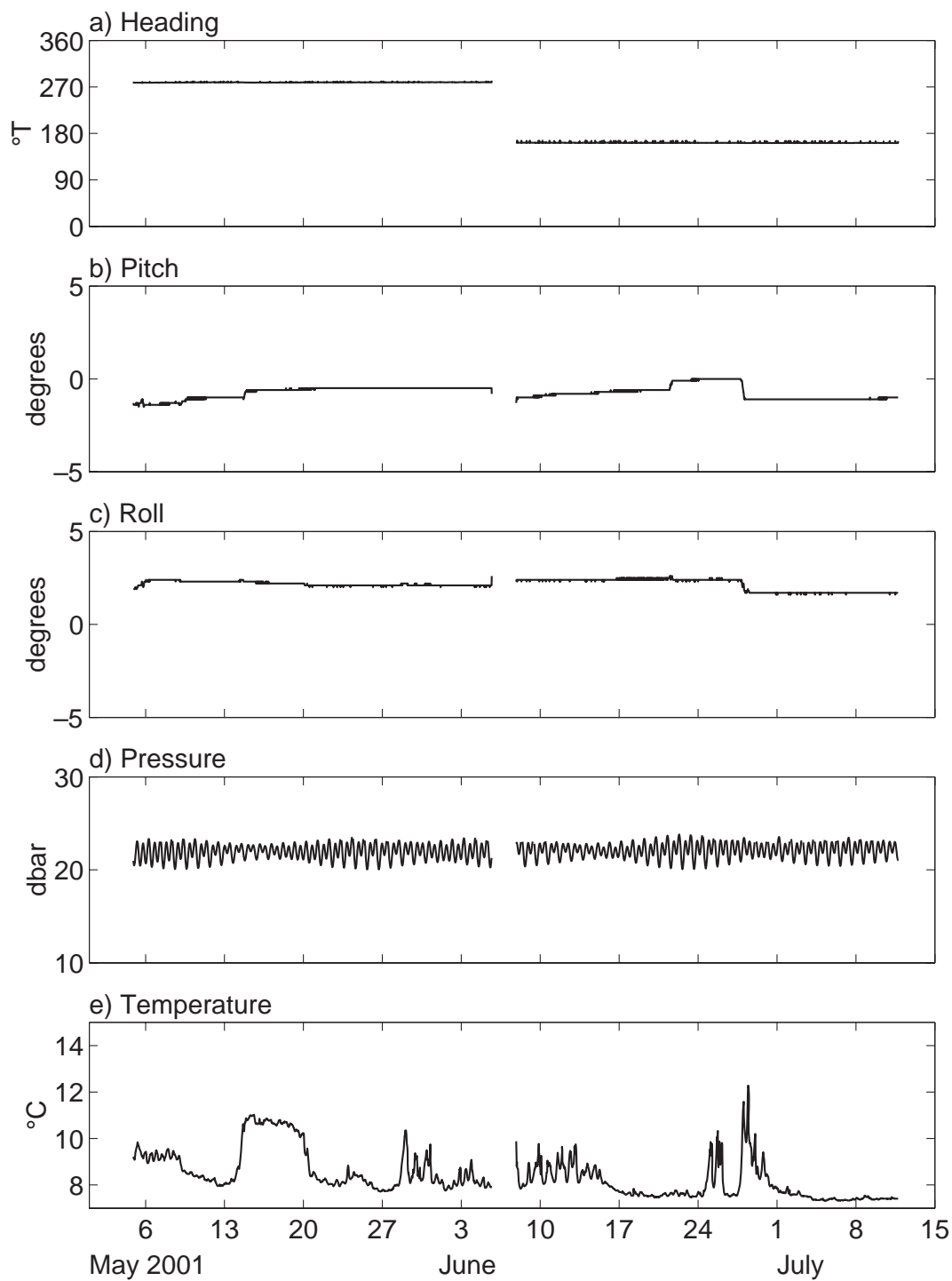


Figure 92. Time series of heading, pitch, roll, pressure, and temperature data collected by the acoustic Doppler profiler (ADP) at Site SD. $^{\circ}\text{T}$ —degrees from true north.

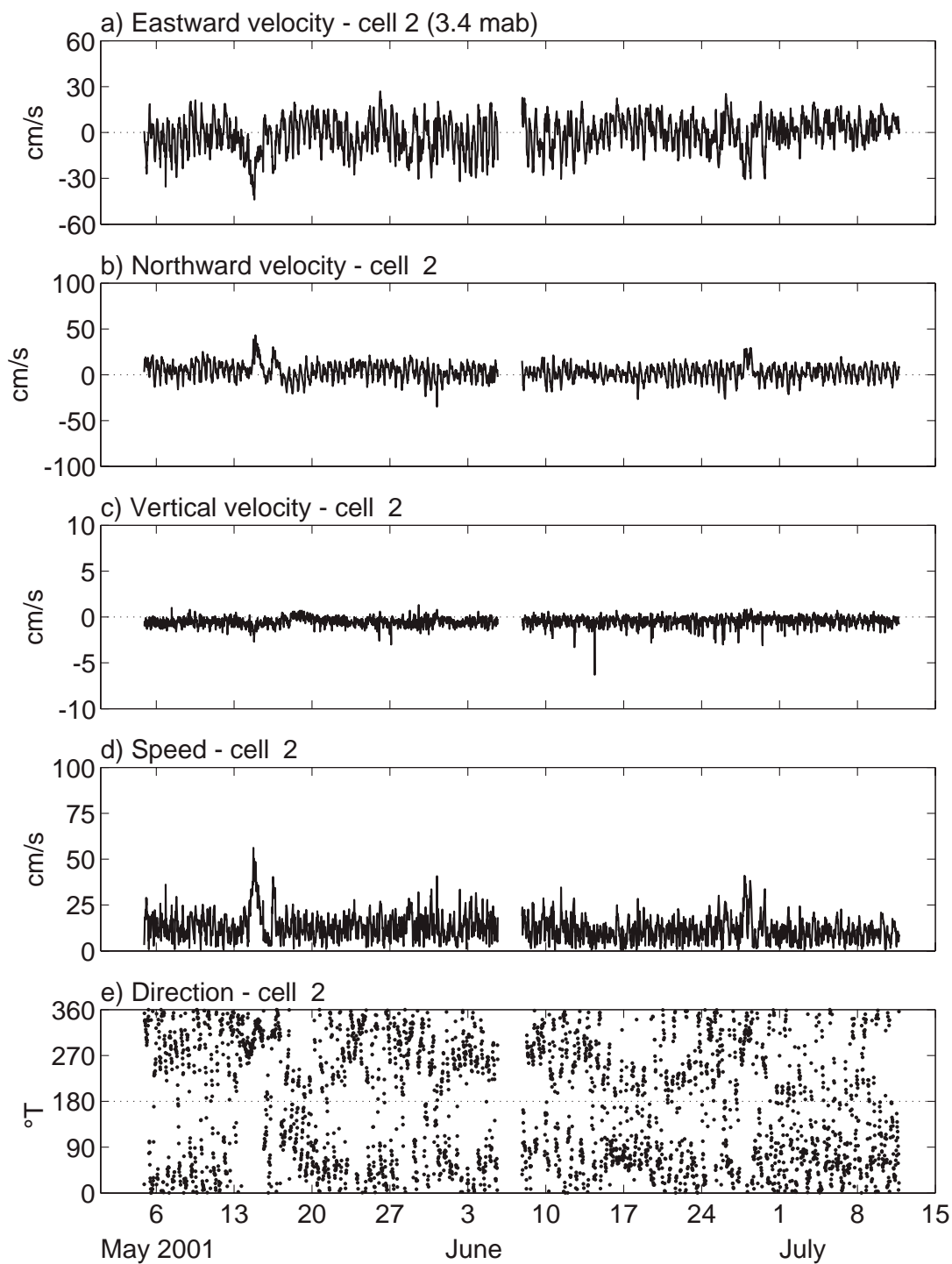


Figure 93. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 2 (3.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site SD. °T—degrees from true north.

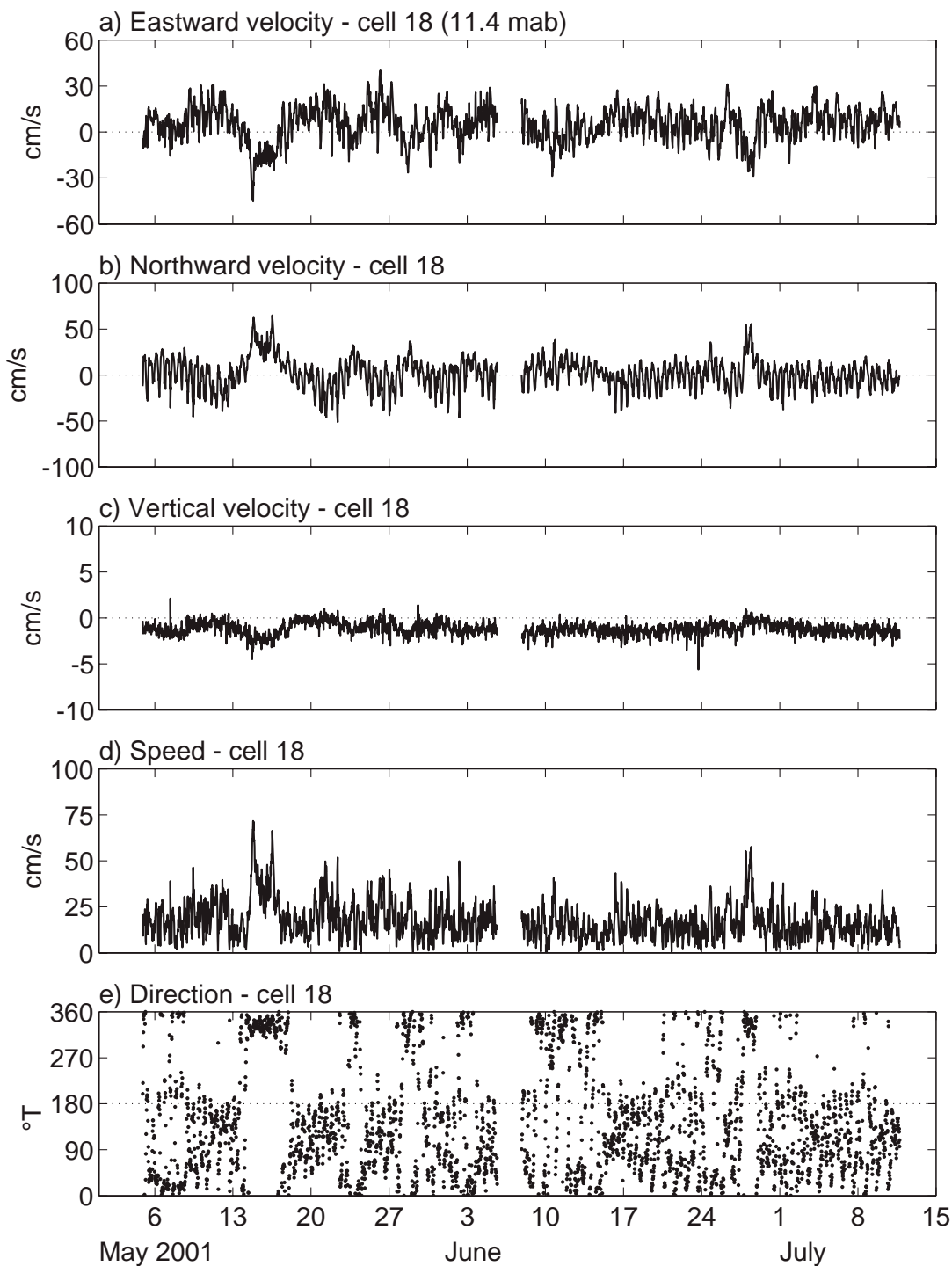


Figure 94. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 18 (11.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site SD. °T—degrees from true north.

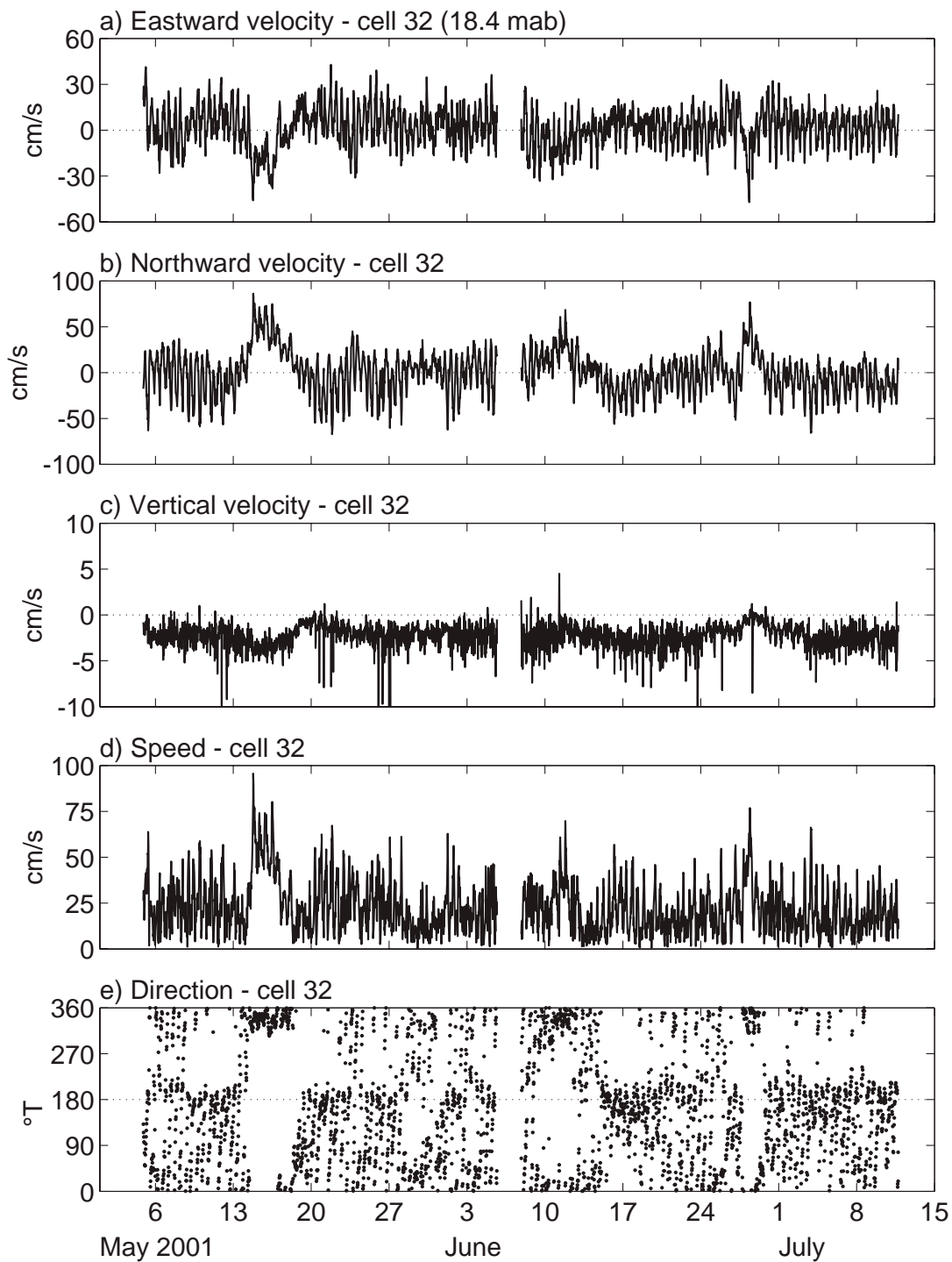


Figure 95. Time series of east (positive eastward), north (positive northward), and vertical (positive up) velocity components, speed, and direction in cell 32 (18.4 mab—meters above bed) from data collected by the acoustic Doppler profiler (ADP) at Site SD. °T—degrees from true north.

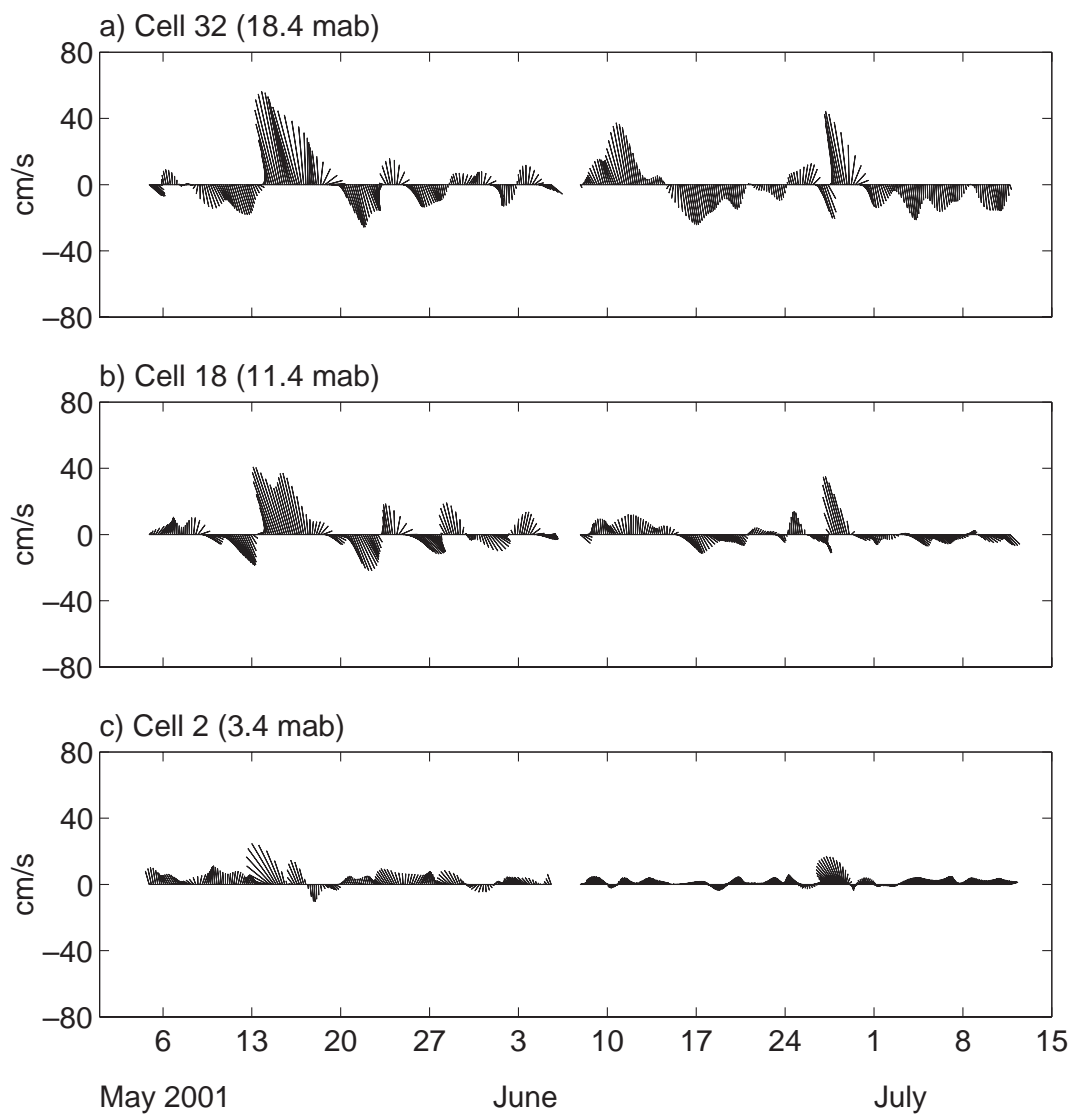


Figure 96. Time series of low-pass filtered velocity for several acoustic Doppler profiler (ADP) cells at Site SD. mab—meters above bed.

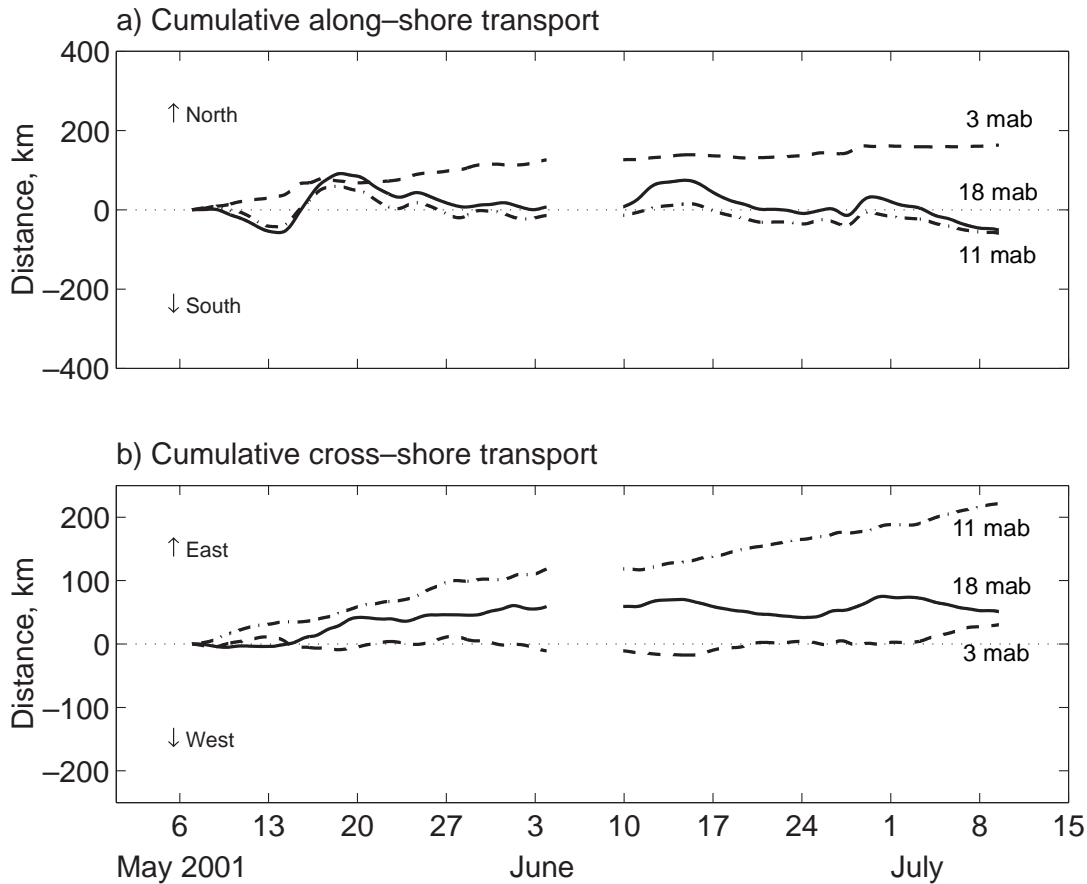


Figure 97. Time series of cumulative alongshore and cross-shore transport for several acoustic Doppler profiler (ADP) cells at Site SD. Data are presented at heights of approximately 3 (dashed line,-), 11 (dash-dotted line, -.), and 18 (solid line,-). mab—meters above bed.

3.3.7 Sonar

3.3.7.1 Description of Collection and Processing of Sonar Data.

The sonar at Site MIB was designed to capture bed images suitable for estimating roughness. The two deployments produced data from May 10 through 25 and June 7 through 23, 2001, respectively. The files, mib-sonar-may.avi and mib-sonar-june.avi, which are located on DVD01, display this data in the form of .avi movie files. Most common computer video display programs, including Windows Media Player, can view these files. Figure 98 shows an example frame from the video files. The top of the image is true north. The top image shows a plan view of the bottom under the tripod and the lower image shows a profile of the bottom. Frame collection occurred every 2 hours. However, a data logger problem resulted in loss of numerous frames. The header at the top of each frame provides the time and date in GMT followed by the day number, also in GMT.

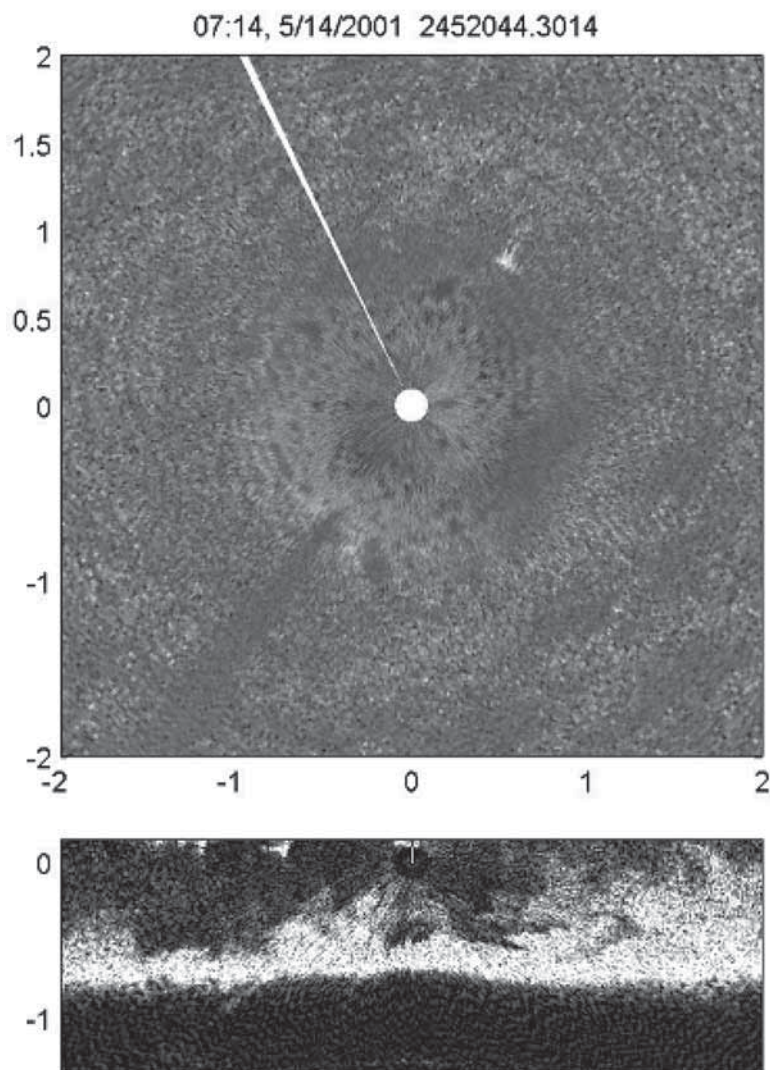


Figure 98. Images showing sample output from sonar at Site MIB. Upper frame shows imaging sonar image; bottom frame shows profiling sonar image. Distances are in meters.

3.3.7.2 Data Presentation

Data analysis began by making images of each scan of the type shown in the videos. Placing the scanned image above the profile image facilitated comparison of the two images. Scanned images were cropped to a 4 m by 4 m area because the region beyond this area lacked clarity. The bed was typically about 0.8 m below the transducer. Analyzing about 140 degrees of head revolution in the profiles included about 4 m of bed and offered a good compromise between range and data quality. The 90 degrees of arc closest to vertical provide the best record but including additional angle allows resolution of larger bed forms. The individual images were assembled to create the .avi files.

At each sampling time the sampling protocol called for 3 scans by each head. These were to be combined to reduce noise in the final image. Each scan took 45 seconds to complete, much longer than individual resuspension events which occur on the order of a wave period. A pointer error in the data storage algorithm resulted in some overwriting of data. Therefore, either one or two scans were available for constructing each image. The image analysis program determined the number of scans available and calculated averages as appropriate. Scans had variation in image intensity. An image enhancement algorithm calculated the average of all values equidistant from the transducer,

subtracted it from each value then divided the difference by the standard deviation of the equidistant values. The videos display these normalized values.

Four types of bed conditions were identified in the profiles—rippled, irregular, megaripples, and flat bed. The rippled bed had clearly identifiable linear ripples in the scan profile. The irregular ripples had a similar texture to linear ripples but lacked long crests. Megaripples presented a smoother and lighter appearance in the scans but with some larger scale irregularity. Flat bed appeared similar to megaripples but lacked large-scale irregularity and showed a flat profile.

Time series of bed profiles (fig. 99) show that bedforms changed over the course of the deployments, but were often stable for several days at a time. White lines indicate missing data. The time series of June profiles prior to 10 June had 16 cm added to correct for settling. The May profile shows bedforms with lengths of about 1 m that appear to be present when waves are approximately 1.5 m high, but appear to wash out during much larger or smaller wave conditions. This feature did not appear in the June data, but a scour pit formed adjacent to the tripod leg under approximately 1.5 m wave conditions.

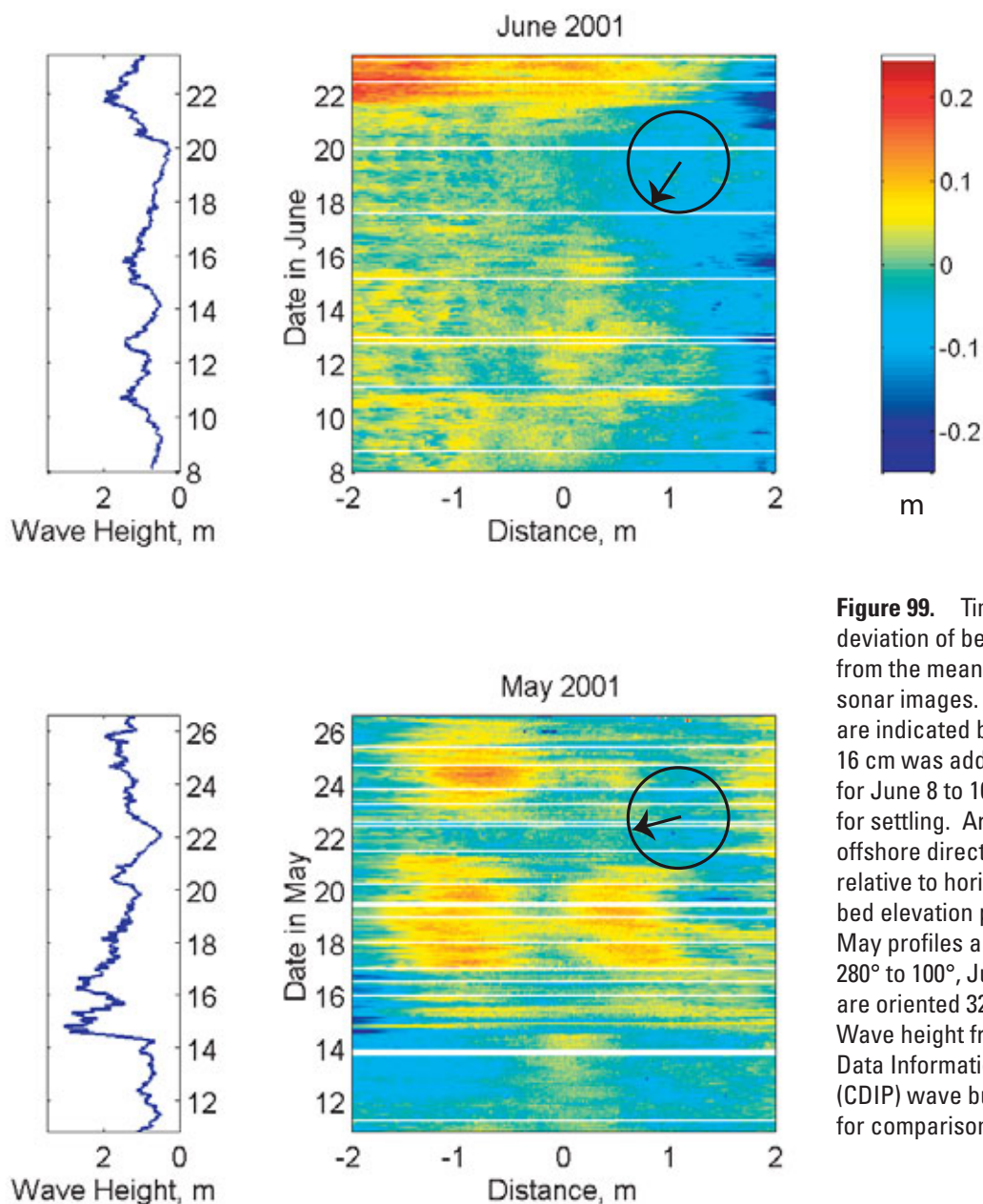


Figure 99. Time series of deviation of bed elevation from the mean, from profiling sonar images. Missing data are indicated by white lines; 16 cm was added to profiles for June 8 to 10 to correct for settling. Arrows show offshore direction (270°) relative to horizontal in the bed elevation plots (that is, May profiles are oriented 280° to 100°, June profiles are oriented 326° to 146°). Wave height from the Coastal Data Information Program (CDIP) wave buoy is shown for comparison.

3.4 Morphology Measurements

3.4.1 Environmental Conditions

Table 32 summarizes the environmental conditions during periods of morphologic data collection.

Table 32. Summary of environmental conditions during morphologic data collection.

[Short-term average temperatures, used for data processing, are shown in bold.]

Date	Time	Boat 1 Profiles Collected	Boat 2 Profiles Collected	Waves				Water
				H_s	T_p	Dir	T_a	Temp
				m	sec	deg	sec	°C
03/29/01	23:16 - 00:22	20, 19, 18, 17		1.77	9.55	285	6.29	9.5
03/30/01	22:53 - 01:52	16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6		1.48	9.10	286	7.56	9.9
03/31/01	21:16	5		1.47	6.25	248	5.11	9.7
								9.7
05/06/01	18:29 - 22:24	15, 13, 12, 11, 9, 7, 5, 3, 2, 1	15_b, 14, 10, 8, 6, 4	1.57	9.24	281	7.96	11.2
05/07/01	19:31 - 22:15	20, 17, 25, 35, 45	20_b, 19, 18, 16, 30, 40, 50	1.00	9.00	274	7.82	11.6
								11.4
05/30/01	01:05 - 02:54	20, 18, 16, 14, 12	20_b, 19, 17, 15, 13	0.95	7.84	258	6.25	13.1
05/31/01	14:45 - 19:43	11, 10, 8, 6, 4, 2, 30, 45	11_b, 9, 7, 5, 3, 1, 25, 35, 40, 50	1.11	9.27	261	6.89	13.1
								13.1
07/07/01	21:47 - 00:15	20, 19, 17, 15, 13, 11		1.85	9.97	292	8.32	12.2
07/08/01	21:29 - 00:45	9, 7, 5, 3, 1	10, 8, 6, 4, 2	1.11	9.09	287	5.94	11.5
07/09/01	21:46 - 01:07	50, 40, 30, 18, 14, 12	45, 35, 25, 18_b, 16	1.24	8.43	294	4.80	11.5
								11.7
08/06/01	20:59 - 22:47	20, 19, 17, 13	20, 16, 15	1.74	10.04	274	8.20	15.0
08/07/01	22:04 - 00:06		18, 14, 12, 11, 10	1.57	8.35	289	6.71	15.1
08/10/01	23:03 - 02:41	9, 8, 6, 4, 2, 25, 35, 45	9, 7, 5, 3, 1, 30, 40, 50	1.14	7.51	297	6.36	15.2
								15.7

3.4.2 Data Coverage

During the spring 2001 experiment, regular topographic and bathymetric surveys quantified both beach and sandbar change during the transition from winter to summer conditions. Weekly topographic surface maps (9 surveys) and monthly nearshore bathymetric surveys (5 surveys, profiles spaced at 200 m) mapped the active nearshore planform from the toe of the primary dune to below the limit of measurable annual change (~12 m mean lower low water—MLLW) within 4 km of the Grays Harbor North Jetty. Six profiles, collected monthly and spaced at 1 km, extended the region of morphology measurements to the alongshore location of Site ND approximately 5 km to the north. Morphology measurements were initiated approximately 1 month prior to the deployment of the instrumented tripods (March 29, 2001) and were continued until one month following instrument retrieval (August 6, 2001). Table 3 gives a summary of beach morphology data collection during the experiment. The alongshore and cross-shore extent of data coverage for the 5

coincident bathymetric and topographic surveys is shown in fig. 100. The remaining topographic beach surface maps have similar footprints as the five shown in the figure.

The seasonal time evolution of each of the nearshore bathymetric profiles is illustrated in figs. 101 through 109. In each of the figures topographic data has been merged with nearshore bathymetric data.

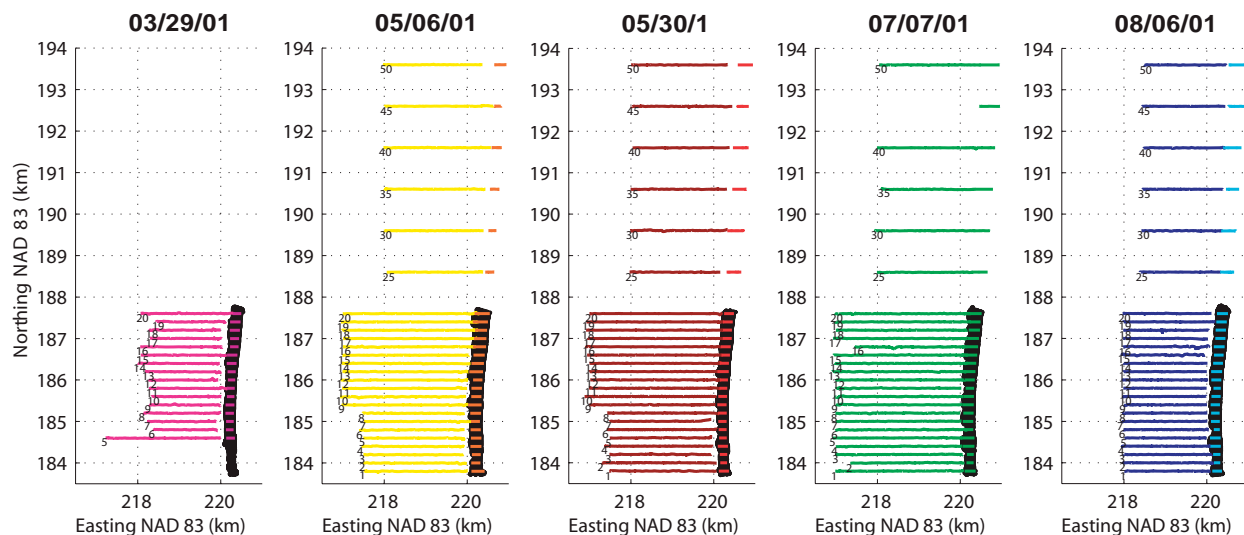


Figure 100. Monthly morphology surveys were performed; the alongshore and cross-shore coverage for the 5 coincident bathymetric and topographic surveys are shown. The remaining topographic beach surface maps have similar footprints as the 5 shown. NAD—North American Datum.

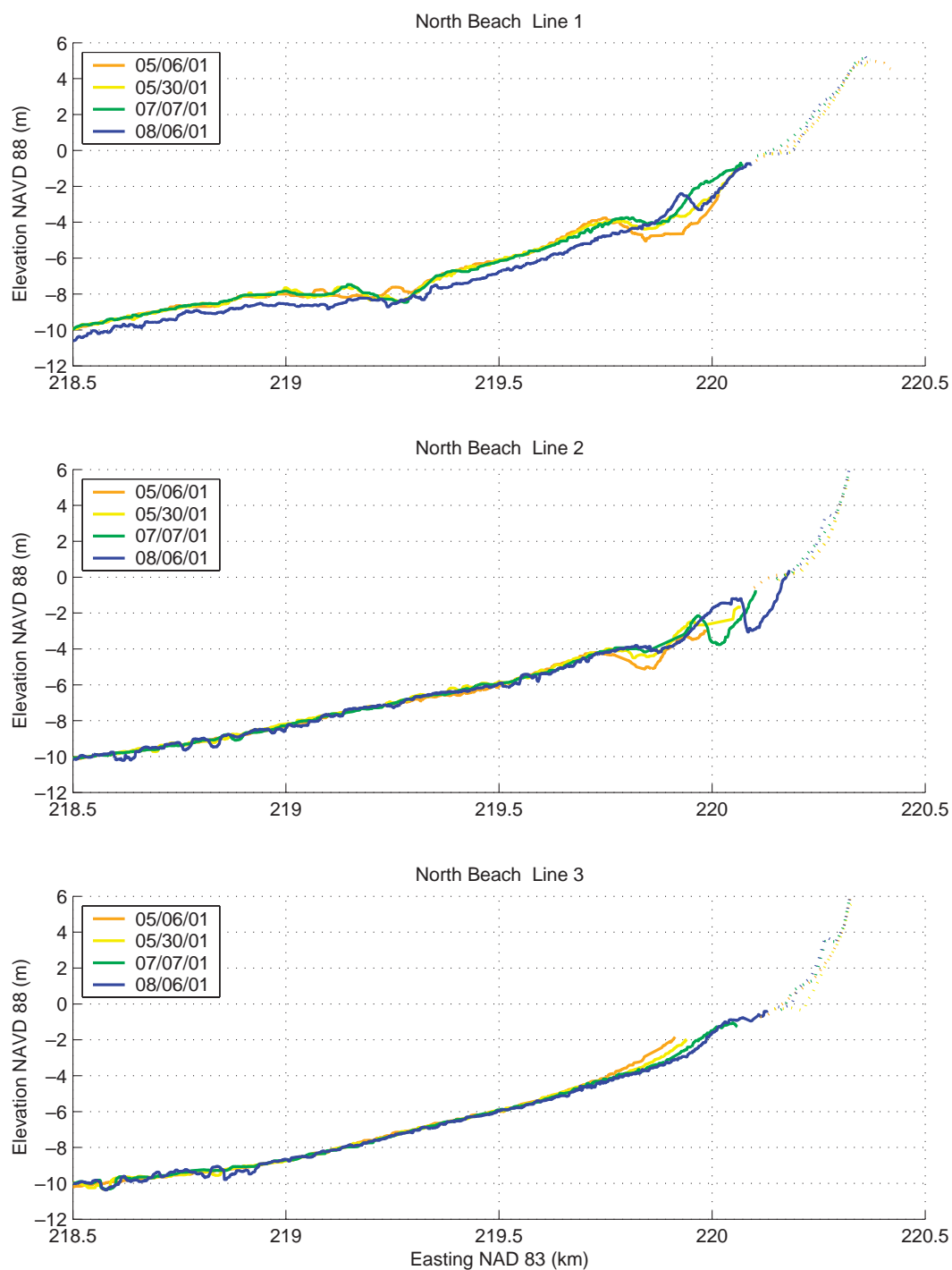


Figure 101. Seasonal time evolution of the nearshore bathymetric profiles at Lines 1, 2, and 3. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical datum.

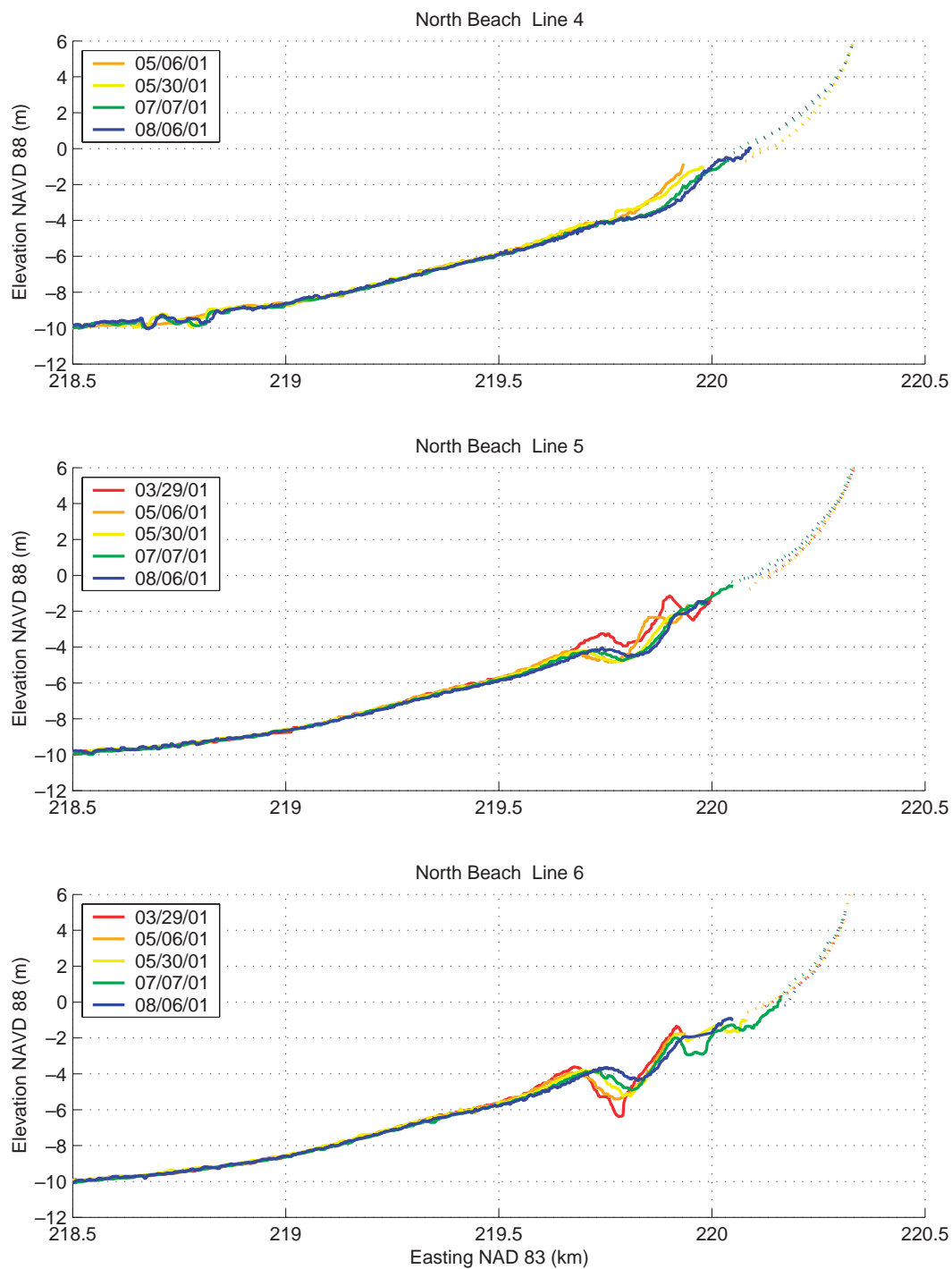


Figure 102. Seasonal time evolution of the nearshore bathymetric profiles at Lines 4, 5, and 6. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

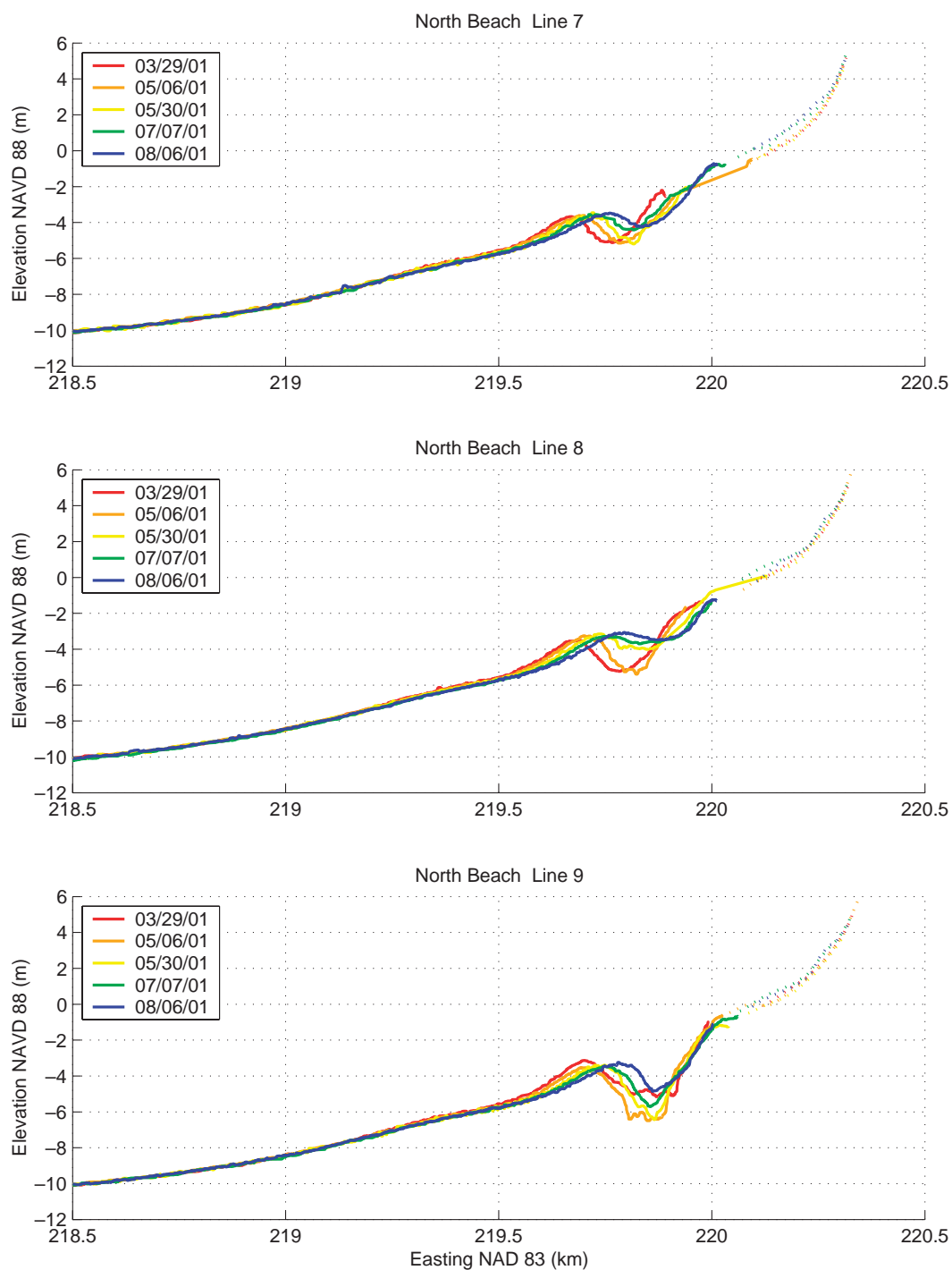


Figure 103. Seasonal time evolution of the nearshore bathymetric profiles at Lines 7, 8, and 9. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

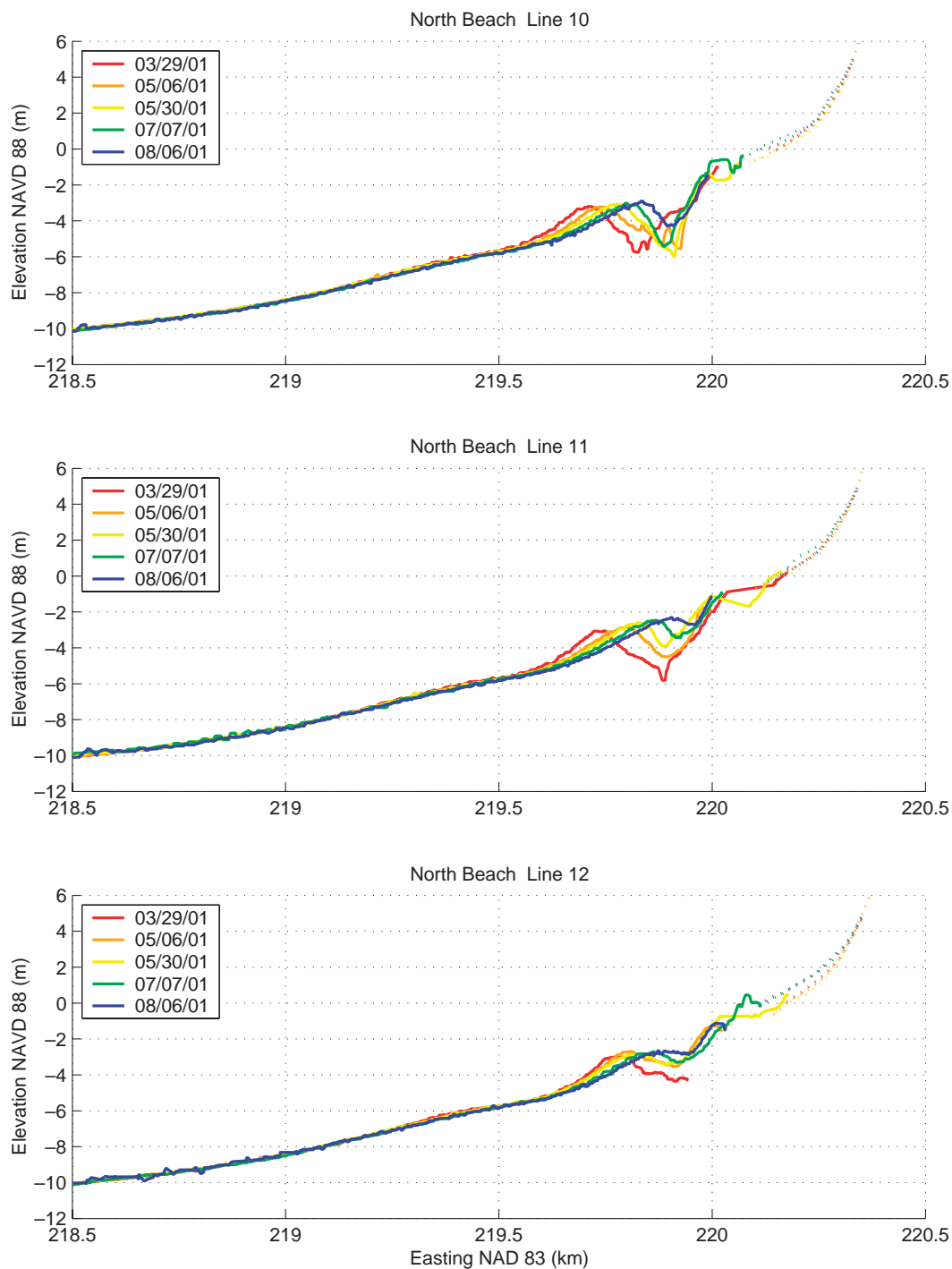


Figure 104. Seasonal time evolution of the nearshore bathymetric profiles at Lines 10, 11, and 12. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

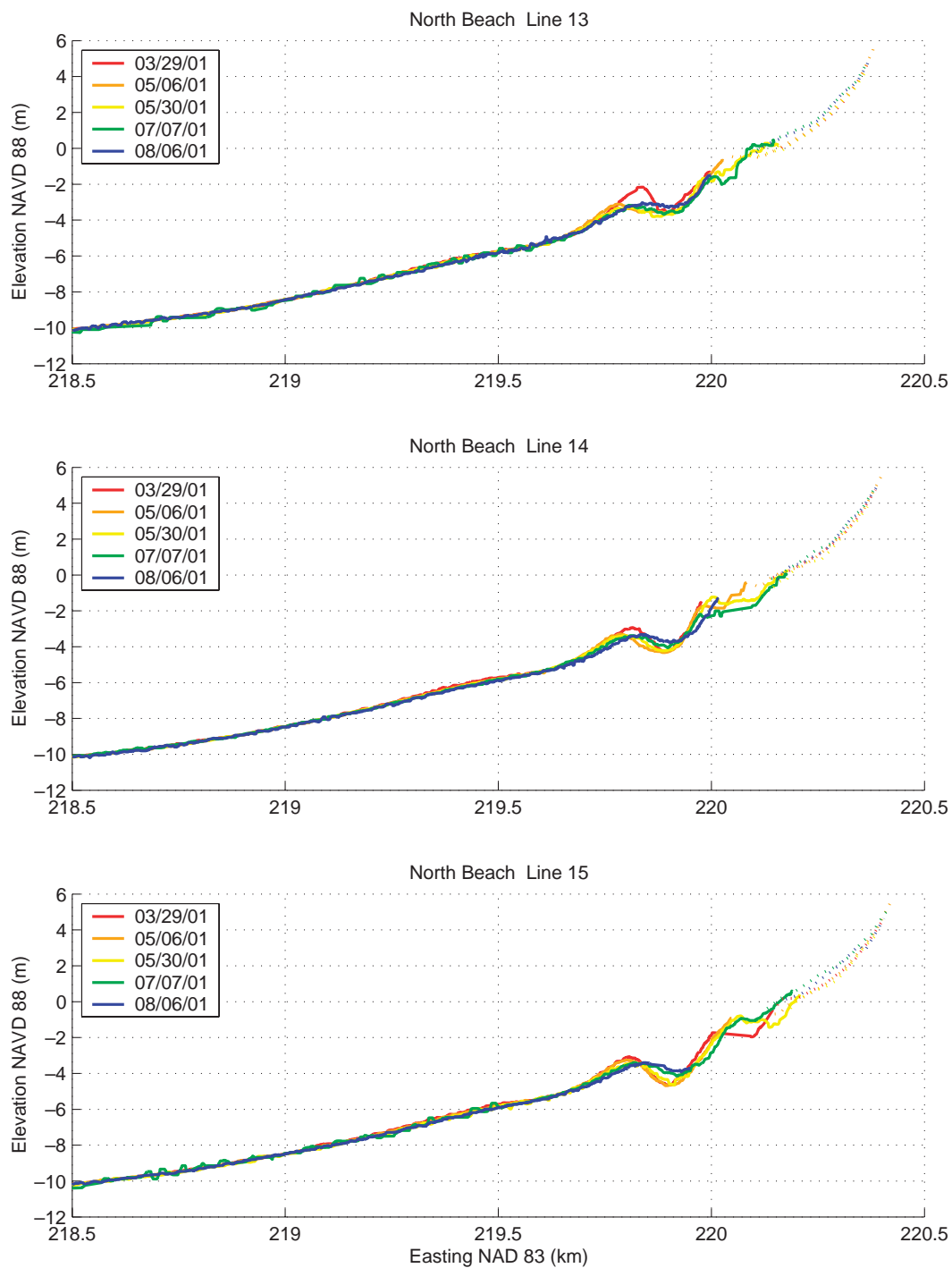


Figure 105. Seasonal time evolution of the nearshore bathymetric profiles at Lines 13, 14, and 15. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

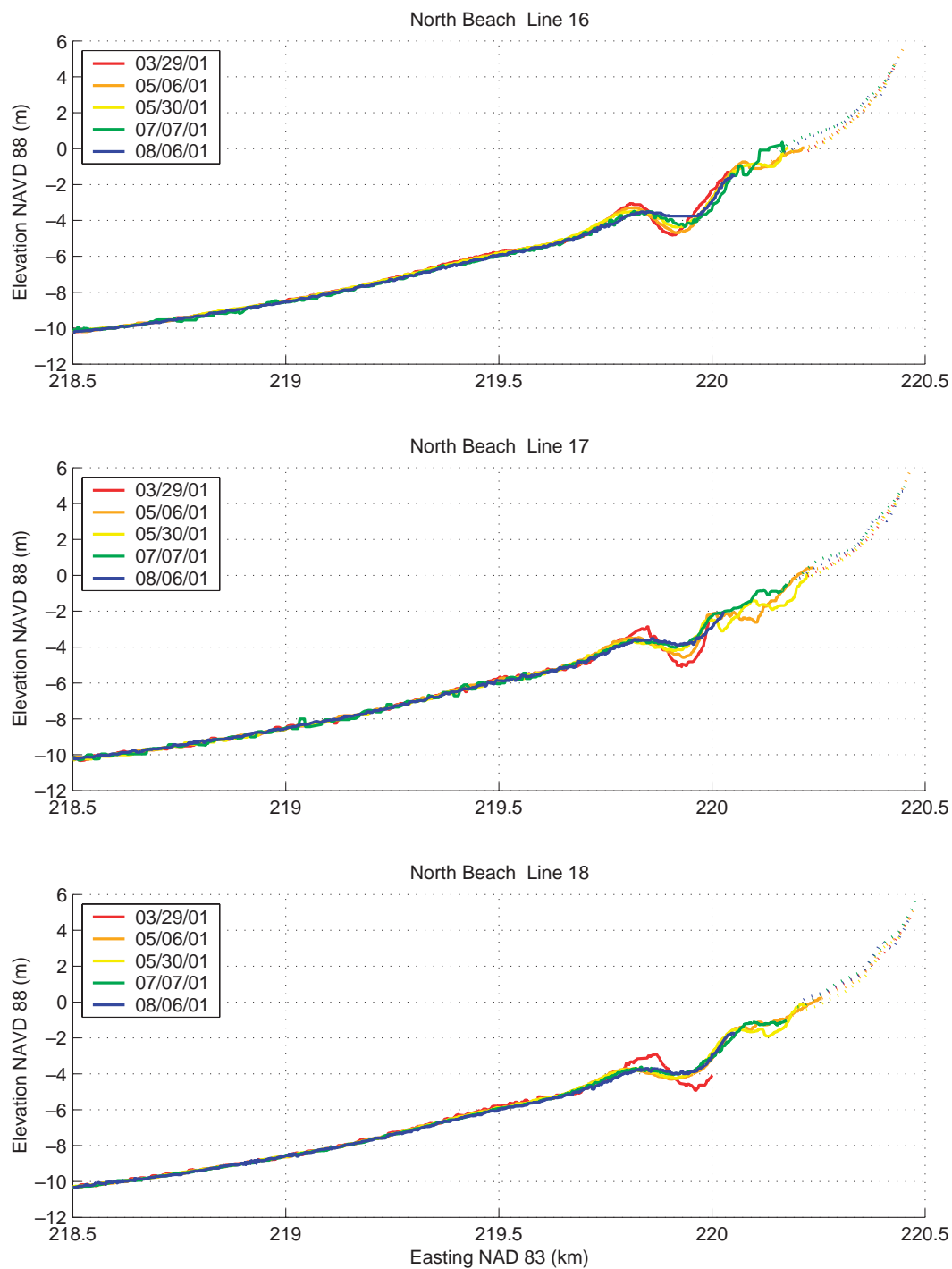


Figure 106. Seasonal time evolution of the nearshore bathymetric profiles at Lines 16, 17, and 18. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

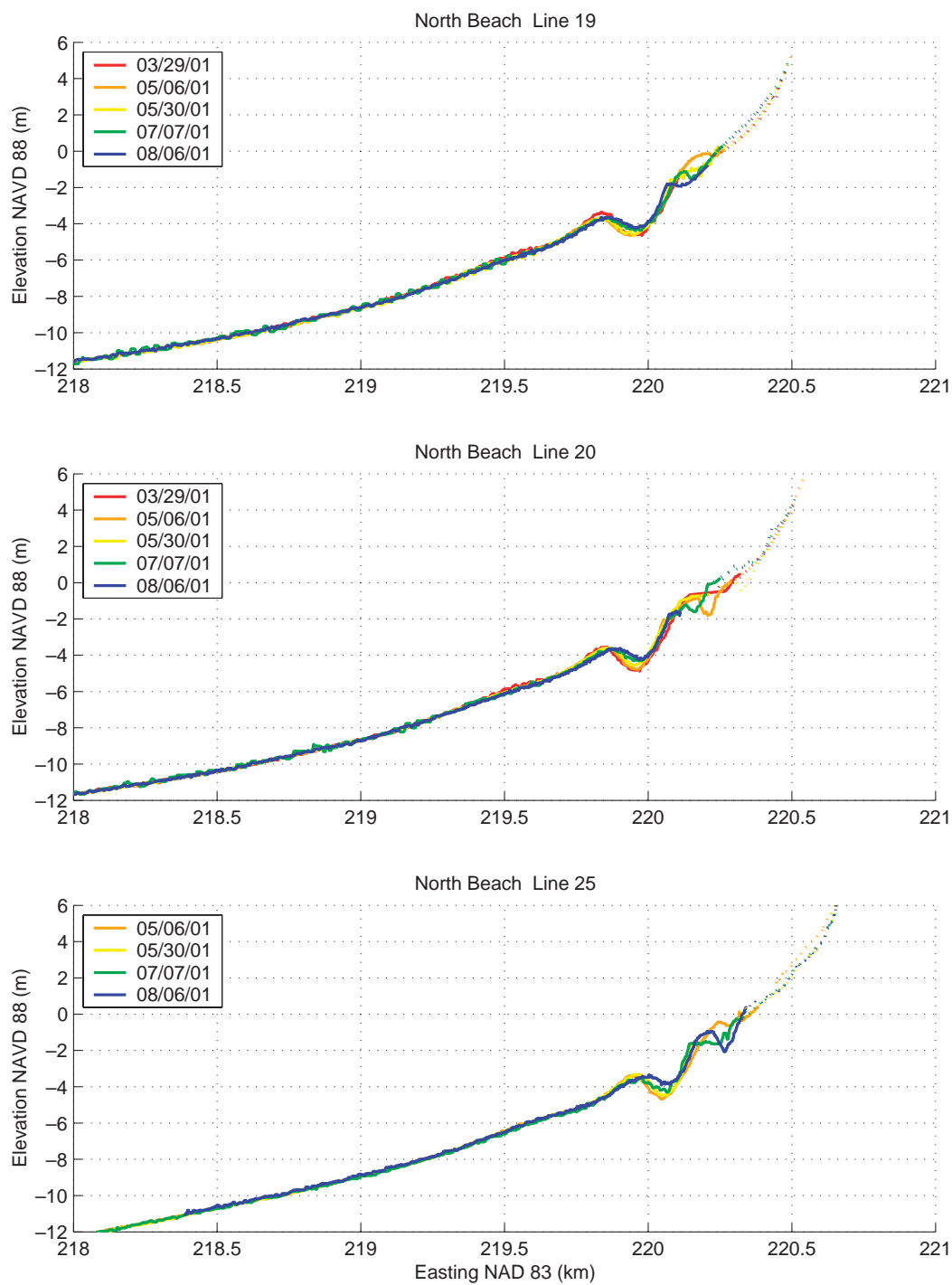


Figure 107. Seasonal time evolution of the nearshore bathymetric profiles at Lines 19, 20, and 25. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

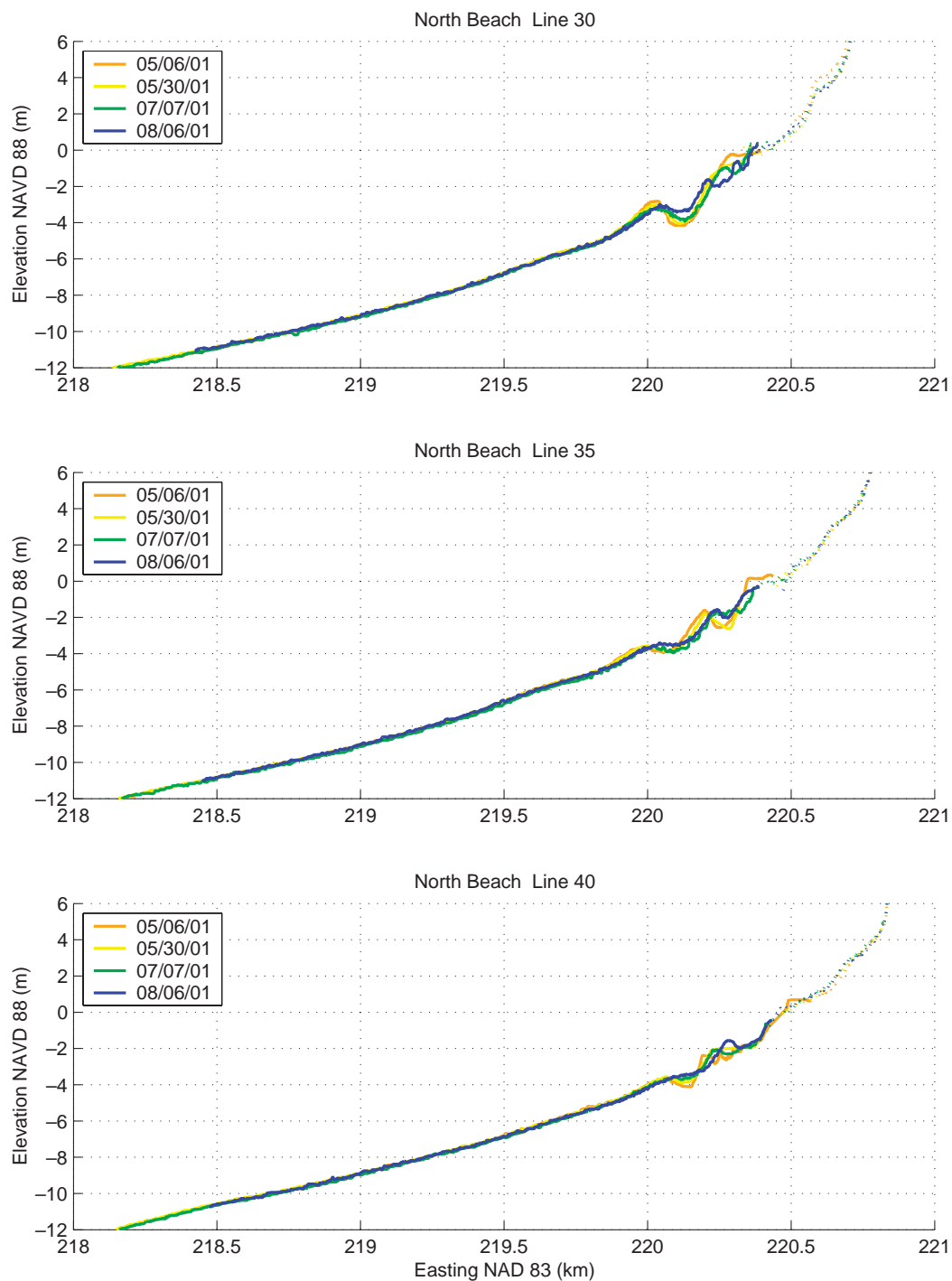


Figure 108. Seasonal time evolution of the nearshore bathymetric profiles at Lines 30, 35, and 40. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

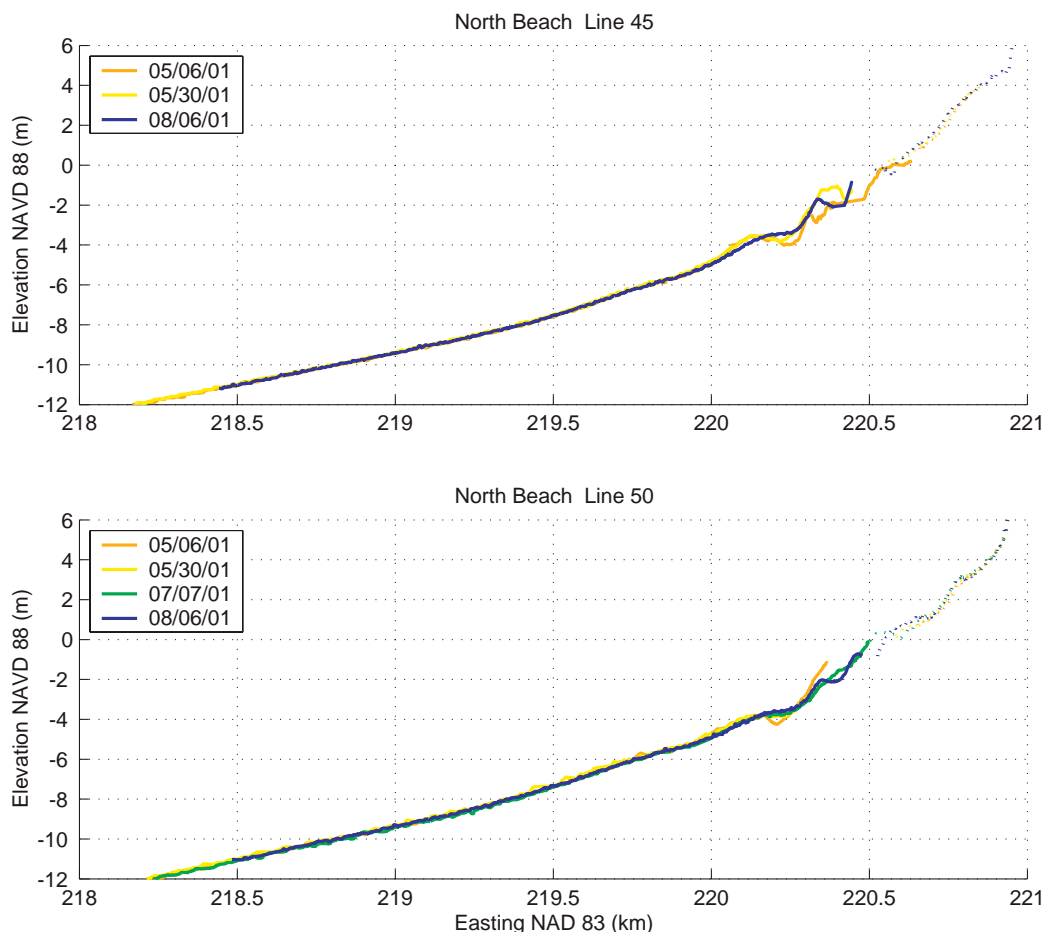


Figure 109. Seasonal time evolution of the nearshore bathymetric profiles at Lines 45, and 50. Topographic data has been merged with nearshore bathymetric data. NAD—North American Datum; NAVD—North American Vertical Datum.

3.4.3 Data Quality

Data quality for topographic beach profiles and beach surface maps was ensured through calibrations (also referred to as horizontal and vertical adjustments) that reduced discrepancies between local control and GPS-derived coordinates. Typically, a field calibration was performed, and if not, the calibration was performed in the office to constrain the horizontal and vertical coordinates with the Washington Coastal Geodetic Control Network (Daniels and others, 1999). A calibration was accomplished by obtaining between two and five calibration points at monuments of known elevation and horizontal position in the vicinity of the survey area. Calibration points were measured by centering the GPS antenna over a known monument at a set height and recording data for several tens of seconds. If the precisions were satisfactory, the point was stored and applied to the survey.

During the spring 2001 campaign, two profile lines on July 7, 2001, were affected by poor GPS resolution, probably due to multipath at the base station. The files were corrected by applying a constant vertical offset that minimizes vertical change high on the beach.

Nearshore bathymetry data quality was ensured by repeating a single profile with both boats once per day. When significant overlap between bathymetry and topography data exists, we inspected the beach profiles for spurious vertical offsets.

Repeat bathymetry lines are included on the DVDs; the naming convention for the repeat lines is nb_date_line#_b.xyz.

PRELIMINARY RESULTS AND DISCUSSION

The primary function of this report is to provide the public with the data collected during the Spring 2001 experiment and enough information to allow for the use of the data. In preparing the report some preliminary observations have been made and are presented here.

CTD profiles (figs. 24 through 26) indicate that water density is mostly controlled by salinity, and less by temperature. Temperature and density are inversely related in these spring-time profiles, a reversal of the relationship observed in winter during the Grays Harbor Wave Refraction Experiment 1999 (Sherwood and others, 2000). In the winter profiles, salinity still controlled density, but the deeper (denser) water was warmer than the overlying, fresher water. Bottom temperatures during the winter 1999 experiment were approximately 11°C, but at the same sites in spring 2001, bottom temperatures were generally cooler and more variable, ranging from 7.5 to 11°C. Conditions during the winter 1999 experiment were characterized by large storms with winds and large waves from the southwest, favorable for wind-induced mixing and coastal downwelling that acted to remove stratification.

The spring 2001 CTD data are evidence that stratification occurs during milder summer wind conditions. Under stratified conditions, velocities at the top of the water column are decoupled from those at the bottom. Progressive vector diagrams (fig. 110) of currents at various heights at Sites ND, MD, and SD demonstrate this. Near-bottom currents (0.5 mab from the ADVO in green and 3 mab from the ADP in blue) tend to travel in the same direction. Currents higher in the water column (red and black lines, from midwater and near-surface ADP bins) also tend to travel in the same general direction, but this direction differs from that of the near-bottom currents. In general, near-bottom currents flow northward, with a significant offshore component evident at Sites ND and MD. At these same sites, flow in the upper water column is predominantly southward. The greatest divergence between the surface and bottom waters appears during the last two-thirds of the experiment when winds were weaker and less variable. In contrast, current directions varied little with depth at Sites ND and SD (the two sites with ADPs) during the winter experiment.

Several OBS were deployed at various heights on the tripod at Site MIA. The instruments were deployed two apiece with the ADVF and PCADP Hydra systems for a total of 6 OBS during Deployment 1 and four during Deployment 2. The top plot in fig. 111 compares OBS data collected during the first deployment by OBS 1 on the two ADVF Hydra systems. Each was placed on the tripod at a height of 60 cmab but on separate legs. The plot shows a near one-to-one relationship between the measurements as would be expected. The values measured by the OBS on ADVF S/N 244 tend to be slightly higher at high concentration of suspended sediment but lower at low concentrations of suspended sediment. The mean difference between the two sets of measurements is 0.007 kg/m³ with a standard deviation of 0.22 kg/m³.

The bottom two plots in fig. 111 show sections of the OBS burst mean time series collected during Deployment 1. The OBS records are from several heights ranging from 45 to 116 cmab. The upper plot shows a period of high suspended sediment concentrations while the lower shows a time period of lower suspended sediment concentrations.

Wave time series were calculated from the velocity and pressure data collected by the ADVs, with the exception of Site MIA for which PCADP data was used. The results—significant wave height, representative bottom orbital velocity, representative wave period and representative wave direction—are plotted in figs. 112 through 117. (Wave direction was omitted for Site ND because of the bad compass.) Wave heights were calculated from the pressure record using standard spectral techniques. Bottom orbital velocities were calculated from the velocity burst measurements according to Madsen (1994), a spectral technique which accounts for wave-current interactions. Representative period was also determined through spectral analysis of the velocity burst time

series. Wave direction was found by determining the direction of greatest variance in the velocity data for each burst.

Wave heights at all the sites are remarkably similar and do not reveal evidence of shoaling or refraction. The results from all three deep water sites are essentially the same as the MD data plotted in fig. 113. Changes in near-bottom wave-orbital velocity are apparent in the data from the cross-shore transect of Sites MD, MS, and MIA/MIB. Although wave heights change little, orbital velocities increase shoreward, nearly doubling between Sites MD and MS. These increases are accompanied by a decreasing representative near-bottom wave period as water depths decrease.

The spring 2001 experiment captured the transition between the high-energy erosive conditions of winter and the low-energy beach-building conditions typical of summer. This seasonal cycle in environmental forcing generates seasonal cycles in morphodynamics, with offshore and northerly sediment transport resulting in beach erosion during the winter and onshore and relatively weak southerly sediment transport dominating beach recovery during the summer.

During the spring 2001 experiment, milder wave conditions (relative to fall 1999) resulted in between 10 to 20 m of shoreline progradation (fig. 118). While wave heights were low, analyses of the grain roughness Shields parameter show that the threshold for sediment movement was exceeded throughout the experiment, at least at Sites MIA and MIB (J. Lacy, written commun.). Figure 119 illustrates the relative shoreline change experienced during spring 2001 at the Ocean Shores surface map.

Onshore bar migration, trough infilling, and sub-aerial sediment accumulation dominated morphological changes during the spring 2001 experiment as observed in profile view (fig. 120) and plan view (fig. 121). The outer bar migrated onshore approximately 100 m as sediment, scoured from the seaward flank of the initial winter bar, was deposited in the landward trough. This migration produced vertical profile changes of ~1 m. The overall height of the bar decreased from as high as 3 m to less than 1 m, where as the shoreline prograded as much as 25 m. Nearshore plan-form differencing (fig. 122) between the May and August surveys reveals that virtually all morphological change occurred between the -6 m and +3 m (MLLW) contours. Alternating alongshore regions of erosion (indicated by cool colors) and accretion (warm colors) illustrate the predominantly 2-dimensional nature of the bathymetric changes.

We are using a combination of data analysis and numerical model simulations linking both cross-shore and alongshore sediment transport to wave energy, sediment characteristics, and antecedent morphology to investigate the physical mechanisms of morphological change. Initial results suggest that cross-shore sediment transport processes are more important than alongshore sediment transport processes in reproducing the seasonal morphological change observed during the spring 2001 experiment (Ruggiero and others, 2003).

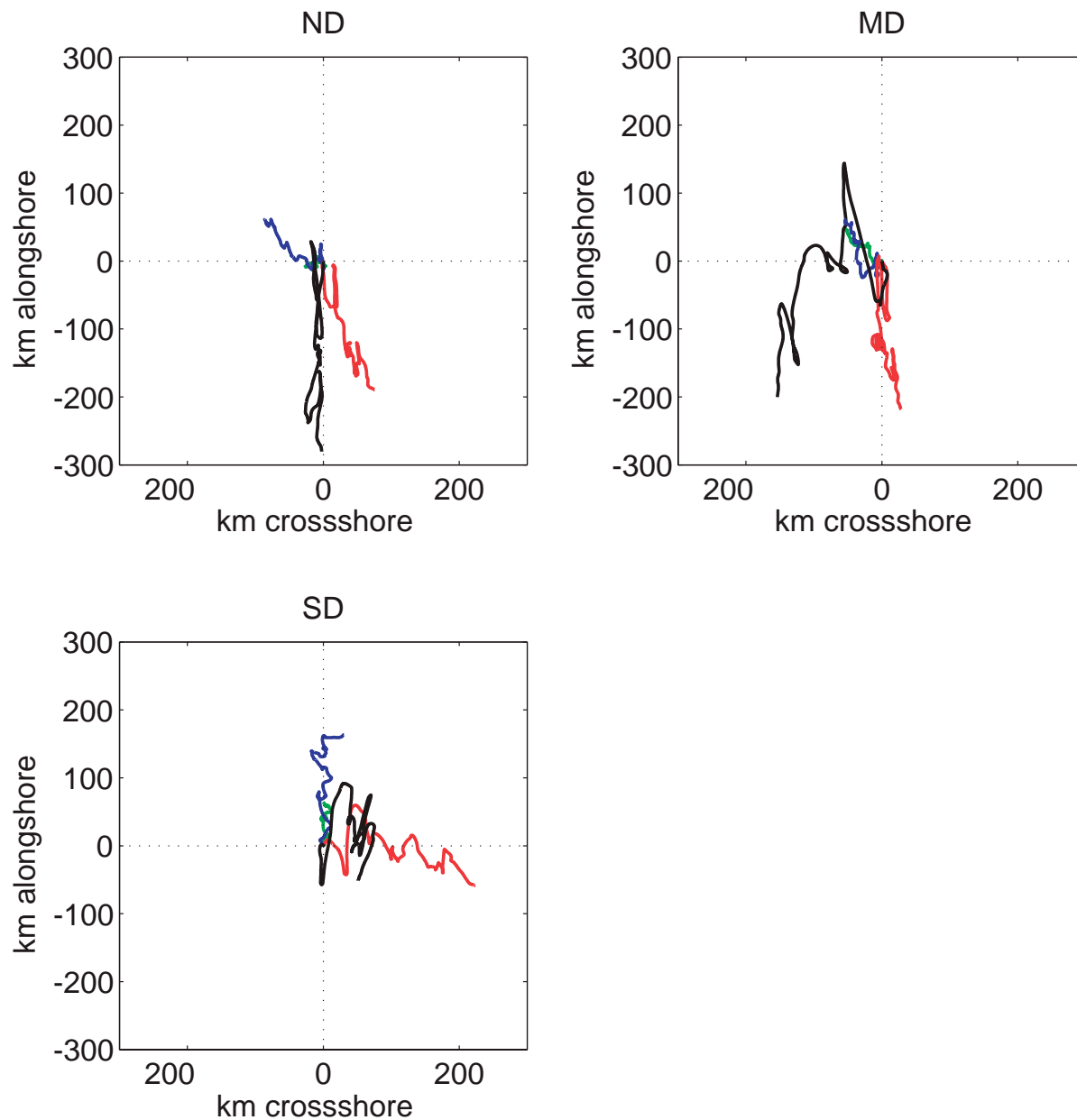


Figure 110. Progressive vector diagrams of tidally-averaged currents at Sites ND, MD, and SD at various heights above the bottom. From the acoustic Doppler Ocean velocimeter (ADVO) data, green is approximately 0.5 mab (meters above bed). From the acoustic Doppler profiler (ADP) data, blue is closest to the bottom (3 mab), red is mid-depth (11 mab), and black is near-surface (18 mab). The alongshore direction at Sites ND and MD is true north ($^{\circ}$ T.); at Site SD the alongshore direction is 330° T.

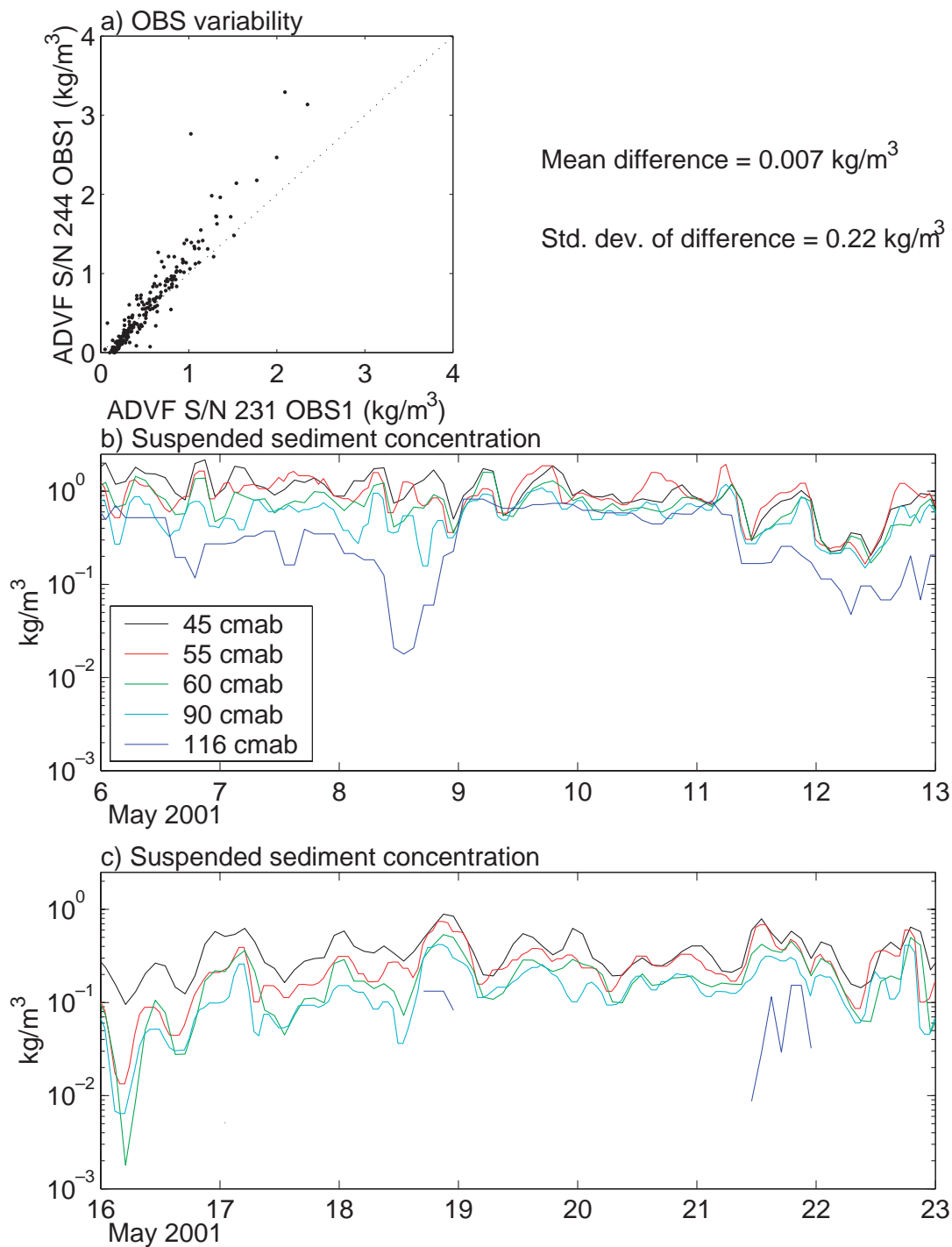


Figure 111. Four to six optical backscatter sensors (OBS) were deployed on the tripod at Site MIA over the experiment allowing for comparison of the OBS data records. The top plot compares two OBS data records collected during Deployment 1 at the same height, 60 cmab (centimeters above bed), but deployed on separate legs of the tripod. The bottom two plots compare two sections of the data records from five OBS collected during Deployment 1 at five different heights above the bed: (b) a period of high suspended sediment concentrations, and (c) a period of low suspended sediment concentrations. At low concentrations, the data from the OBS located 116 cmab generated zero or negative concentrations when instrument calibrations were applied; these data points have been omitted from the plots. ADVF—acoustic Doppler Field velocimeter; S/N—serial number.

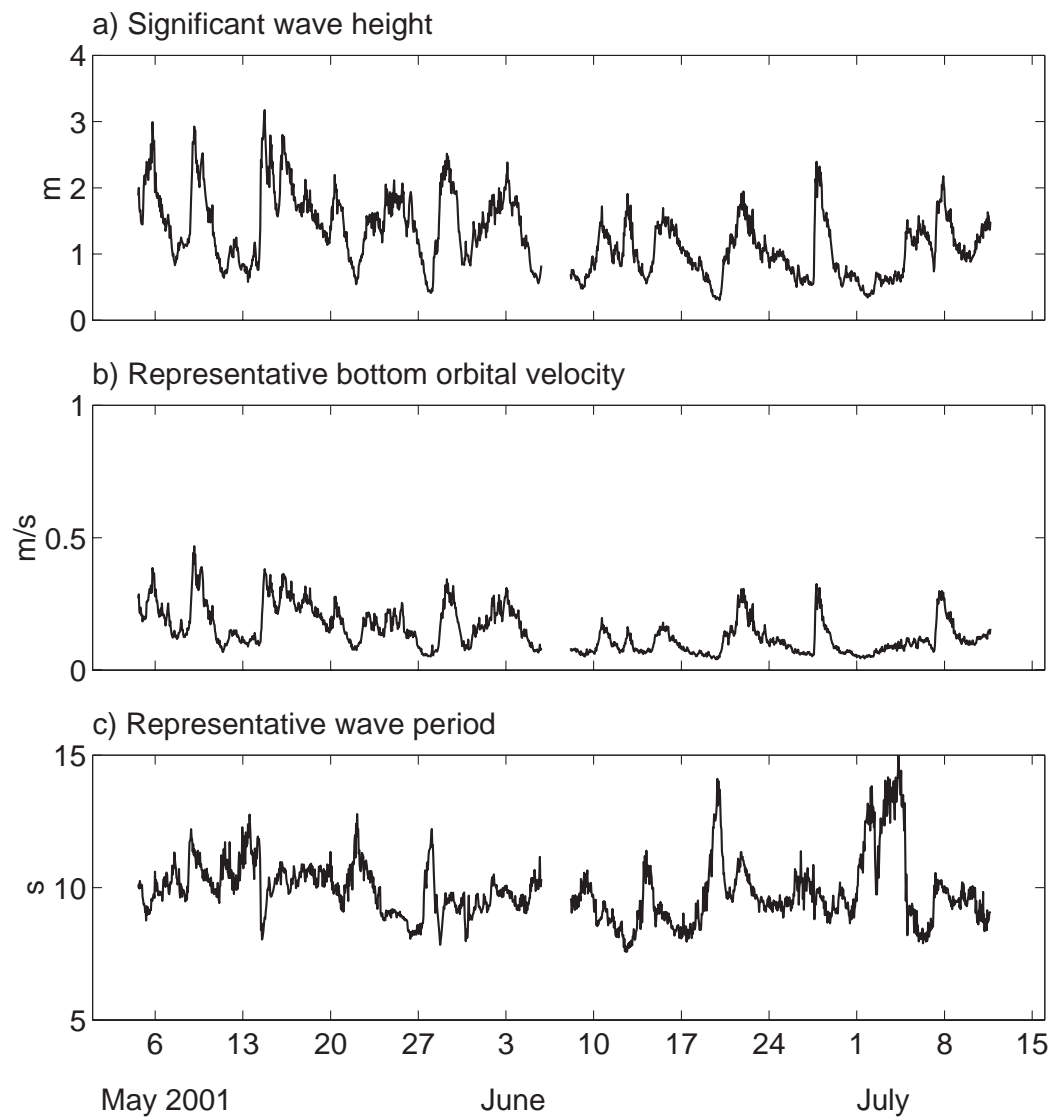


Figure 112. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from acoustic Doppler Ocean velocimeter (ADVO) data collected at Site ND.

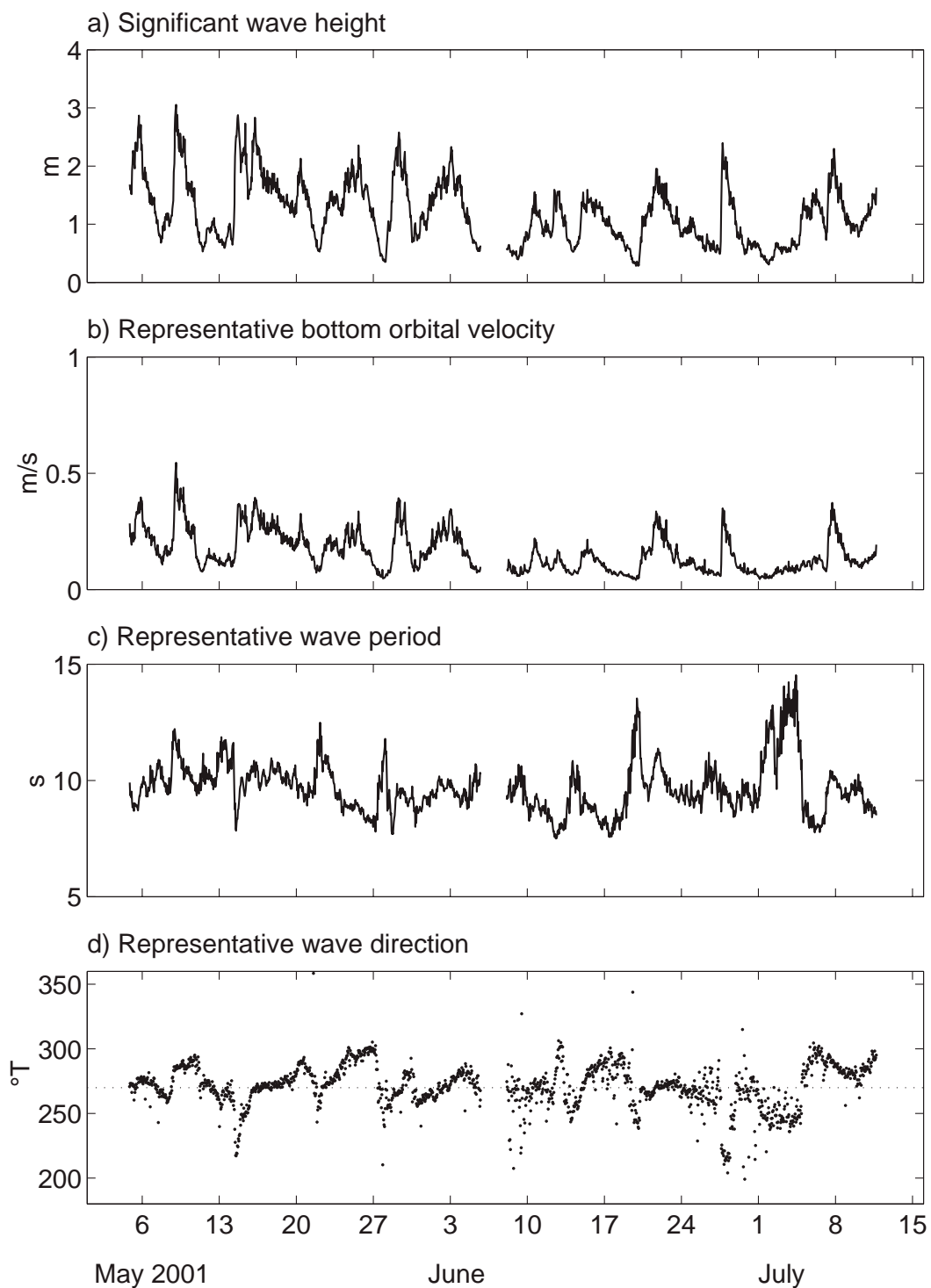


Figure 113. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from acoustic Doppler Ocean velocimeter (ADVO) data collected at Site MD. °T—degrees from true north.

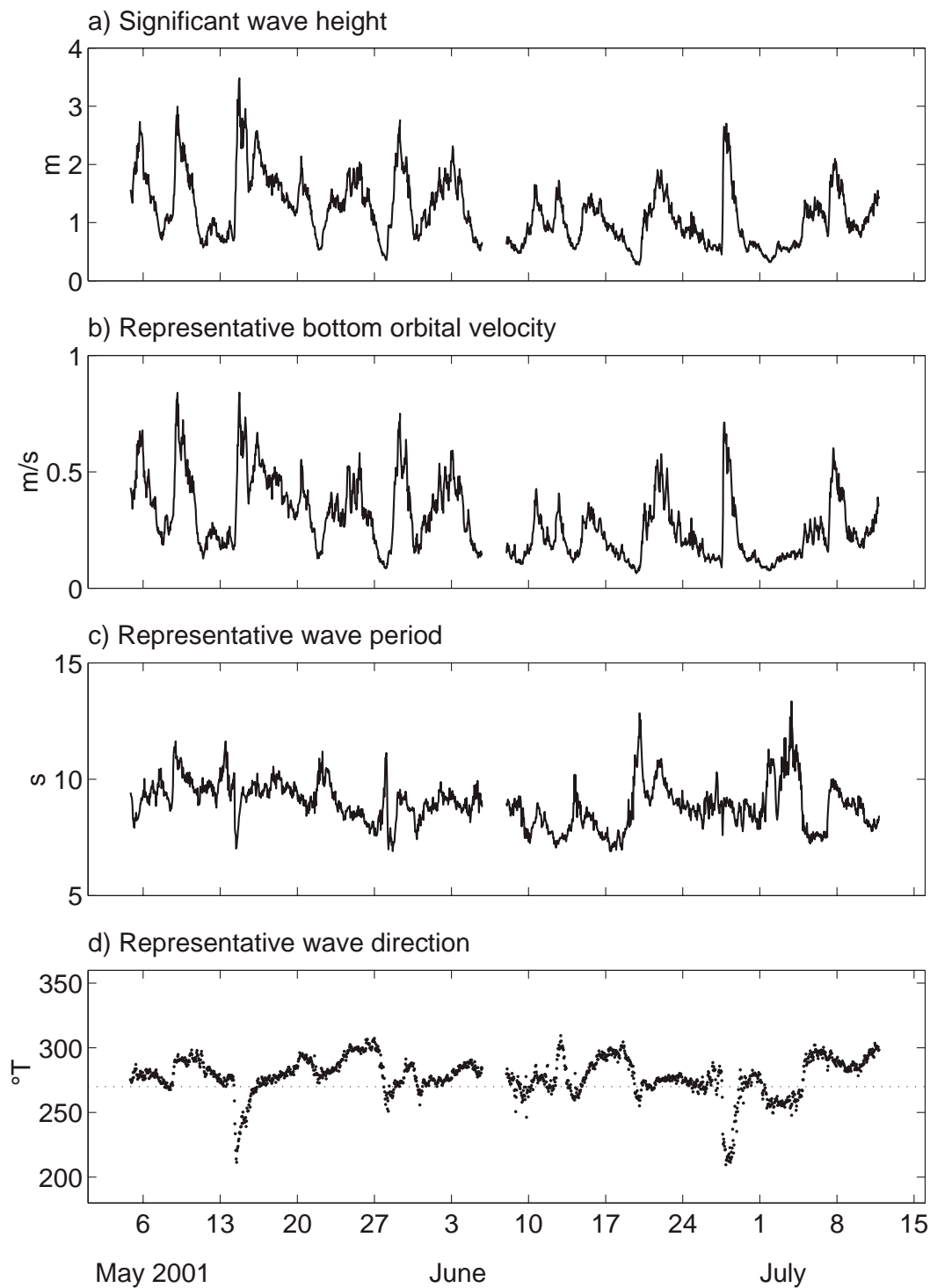


Figure 114. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from acoustic Doppler Ocean velocimeter (ADVO) data collected at Site MS. °T—degrees from true north.

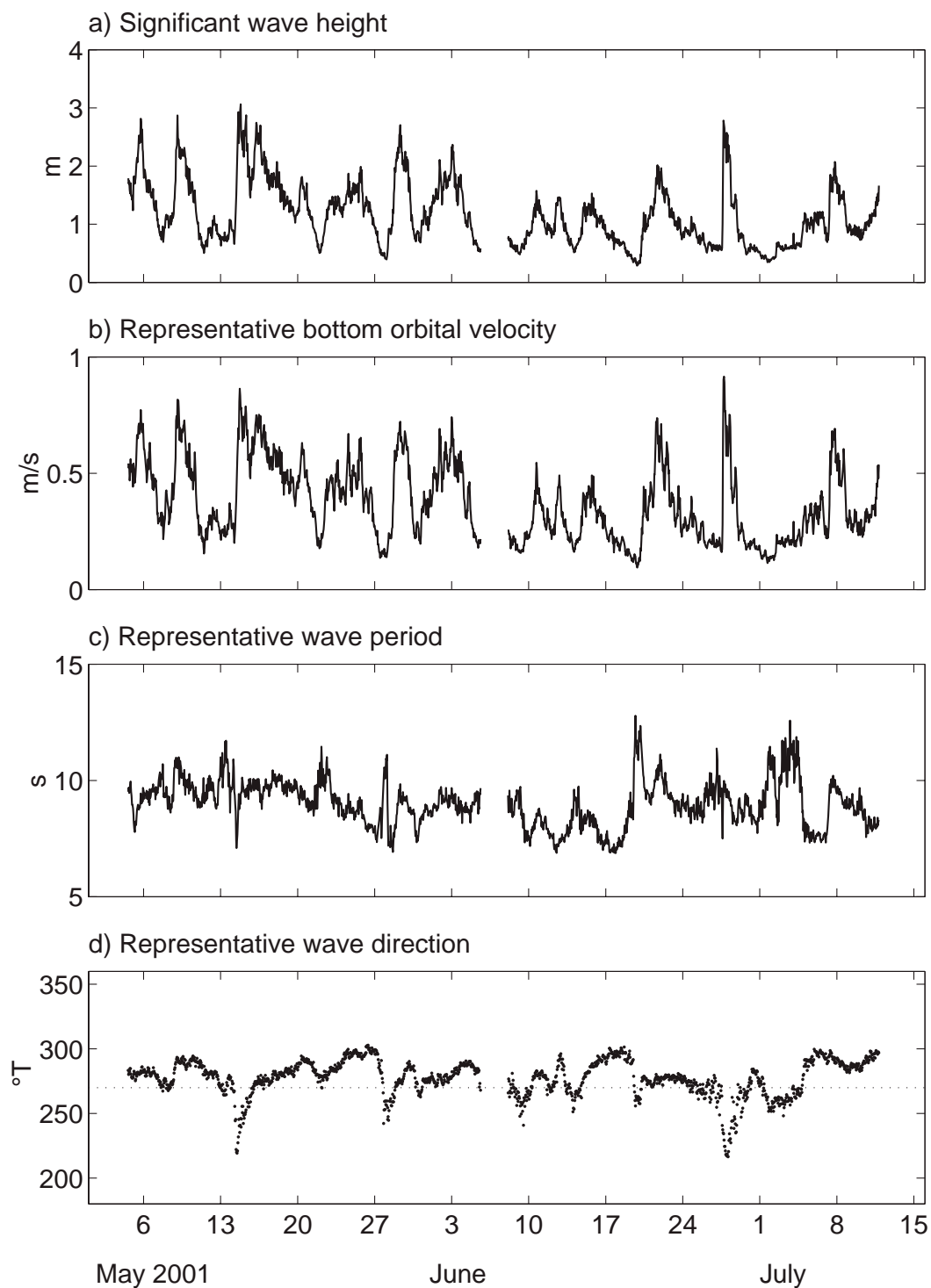


Figure 115. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from pulse-coherent acoustic Doppler profiler (PCADP) data collected at Site MIA. °T—degrees from true north.

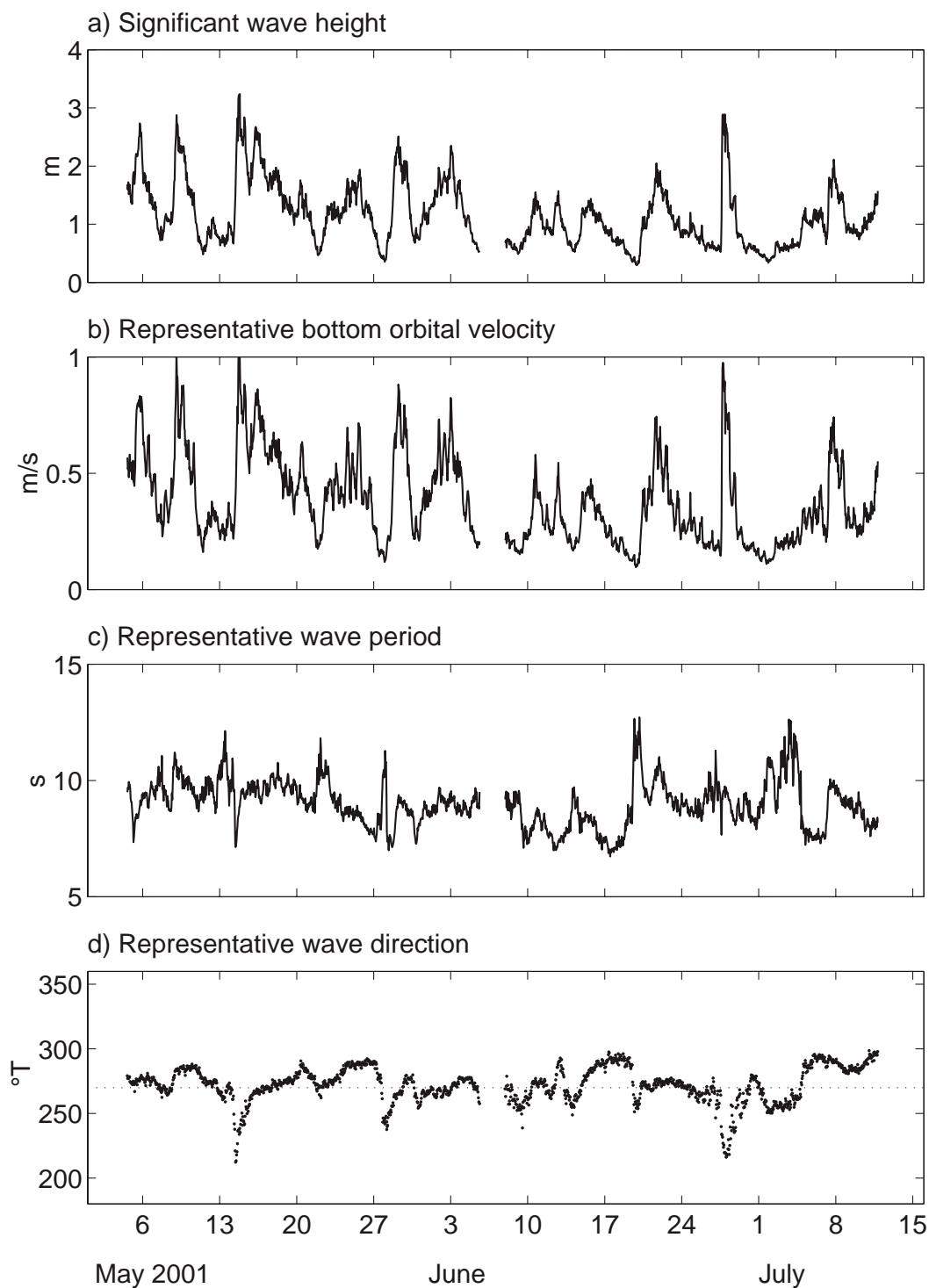


Figure 116. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from acoustic Doppler Ocean velocimeter (ADVO) data collected at Site MIB. °T—degrees from true north.

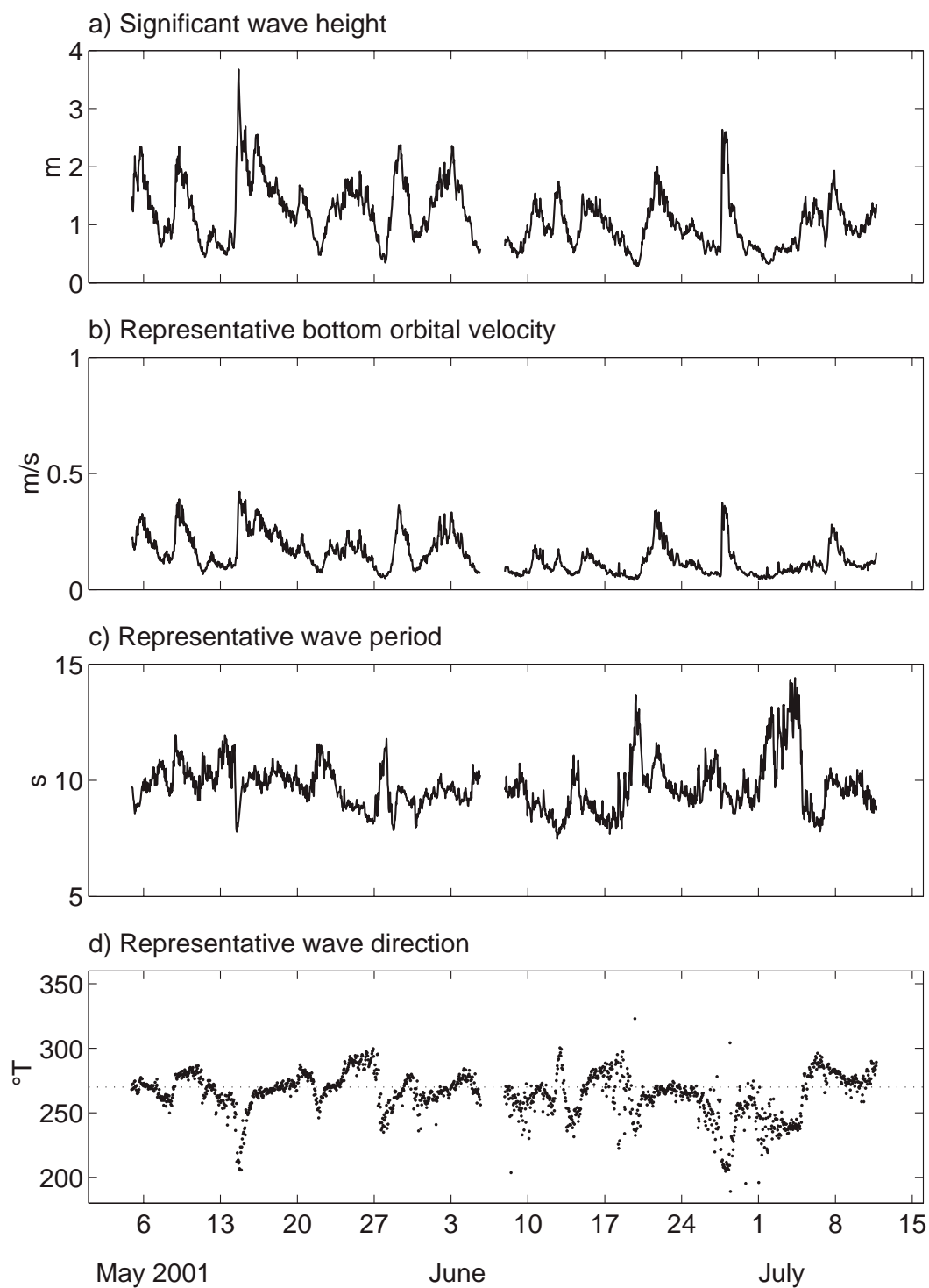


Figure 117. Time series of calculated wave parameters, significant wave height, representative bottom orbital velocity, representative wave period, and representative wave direction, as calculated from acoustic Doppler Ocean velocimeter (ADVO) data collected at Site SD. °T—degrees from true north.

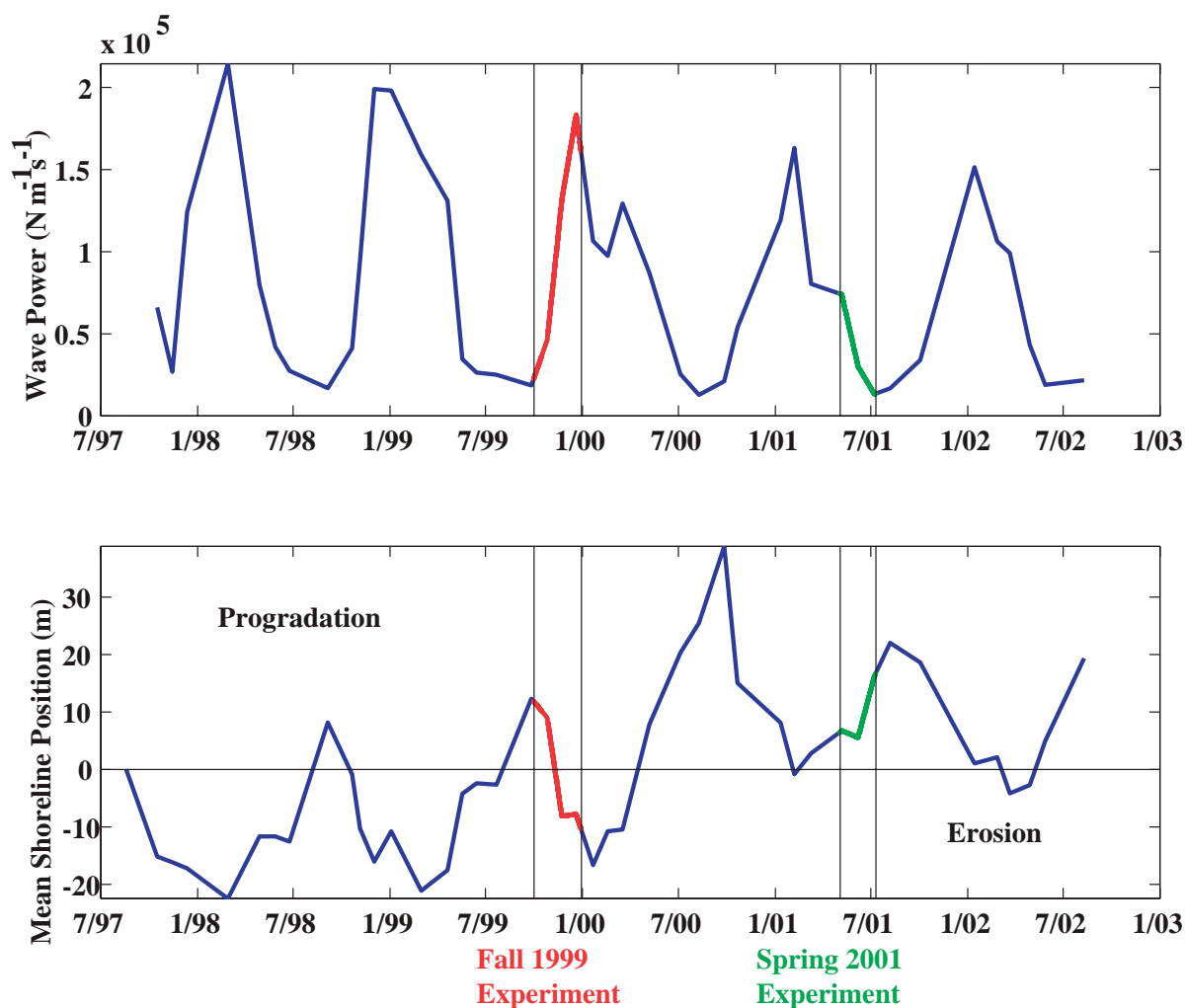


Figure 118. Times series of wave power (at the Grays Harbor Coastal Data Information Program—CDIP—buoy) and mean shoreline position from July 1997 though January 2003. During the spring 2001 experiment, milder wave conditions (relative to fall 1999) resulted in between 10 to 20 m of shoreline progradation. While wave heights were low, analyses of the grain roughness Shields parameter show that the threshold for sediment movement was exceeded throughout the experiment, at least at Sites MIA and MIB (J. Lacy, written commun.).

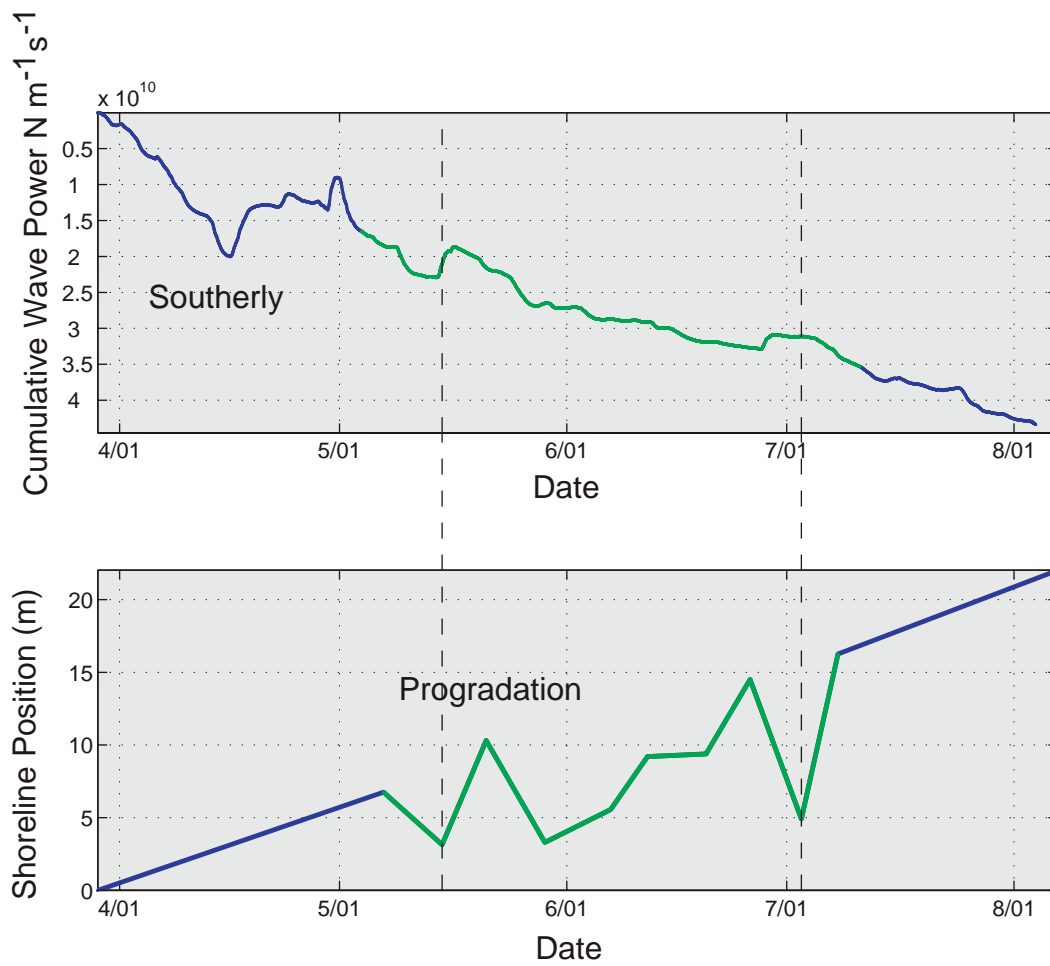


Figure 119. Time series of cumulative wave power (at the Grays Harbor Coastal Data Information Program—CDIP—buoy) and the relative shoreline change experienced during spring 2001 (04/2001–08/2001) at the Ocean Shores surface map.

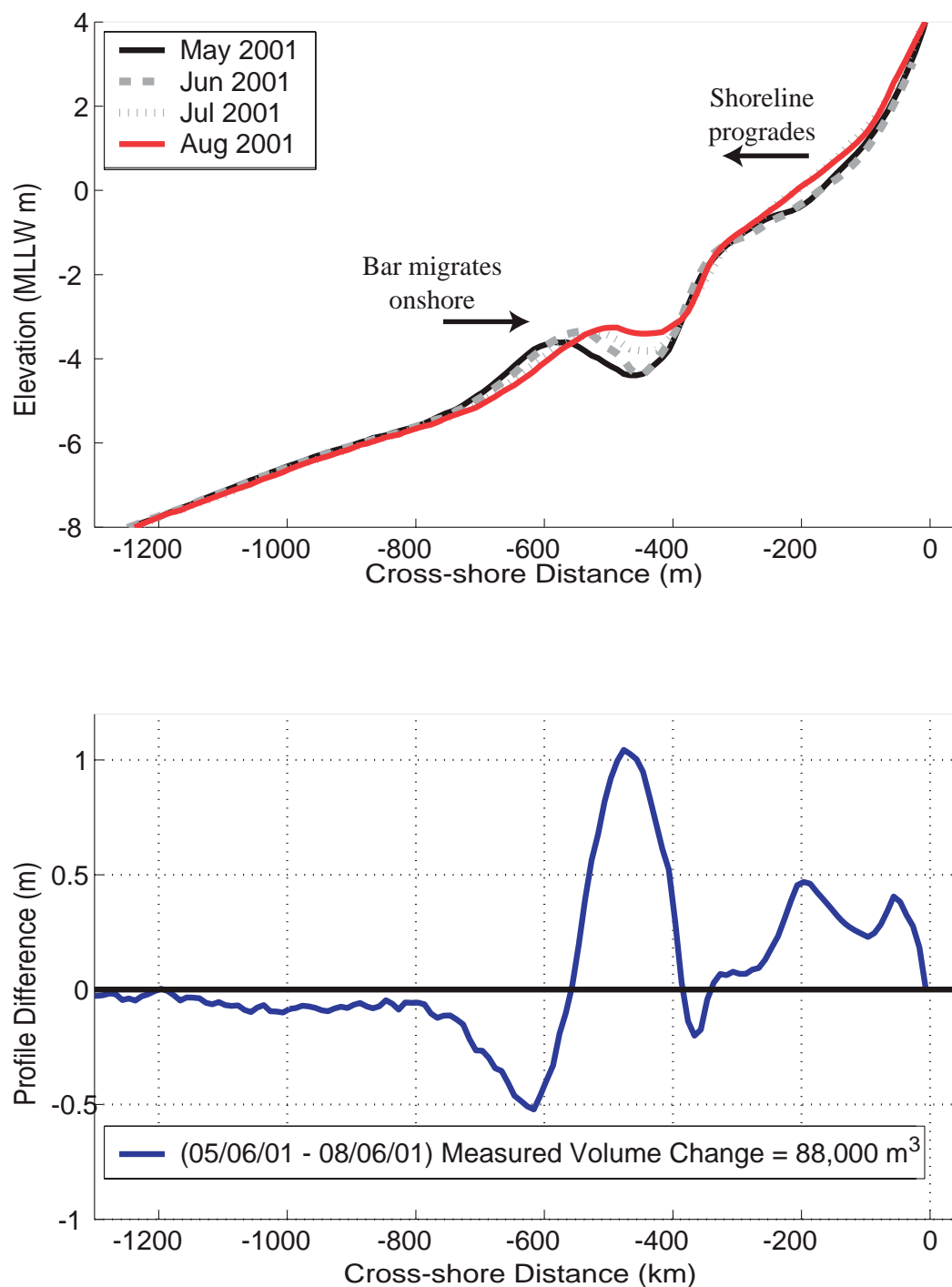


Figure 120. Onshore bar migration, trough infilling, and subaerial sediment accumulation dominated morphological changes during the spring 2001 experiment as observed in profile view (this figure) and plan view (figure 121). MLLW—mean lower low water.

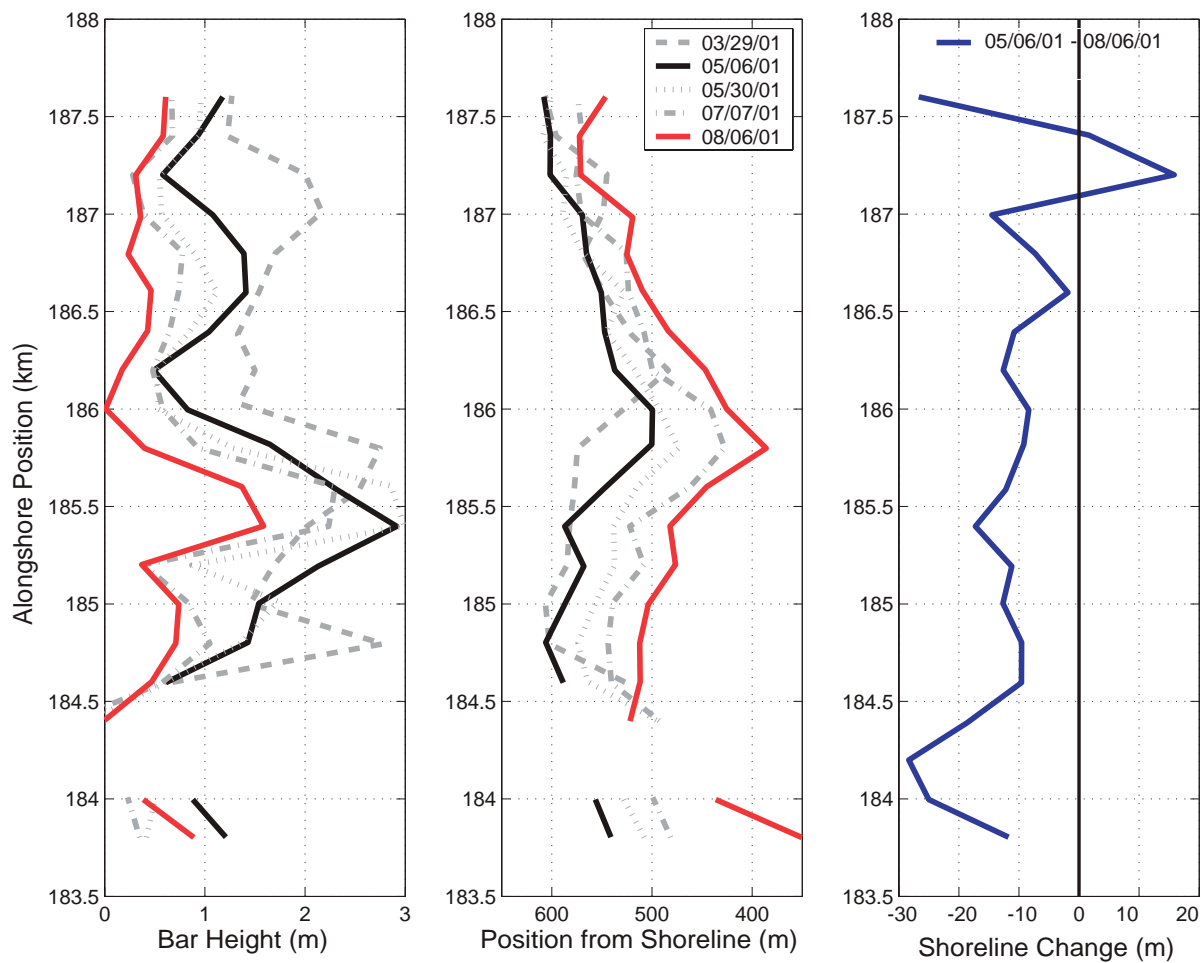


Figure 121. Onshore bar migration, trough infilling, and subaerial sediment accumulation dominated morphological changes during the spring 2001 experiment as observed in profile view (figure 120) and plan view (this figure).

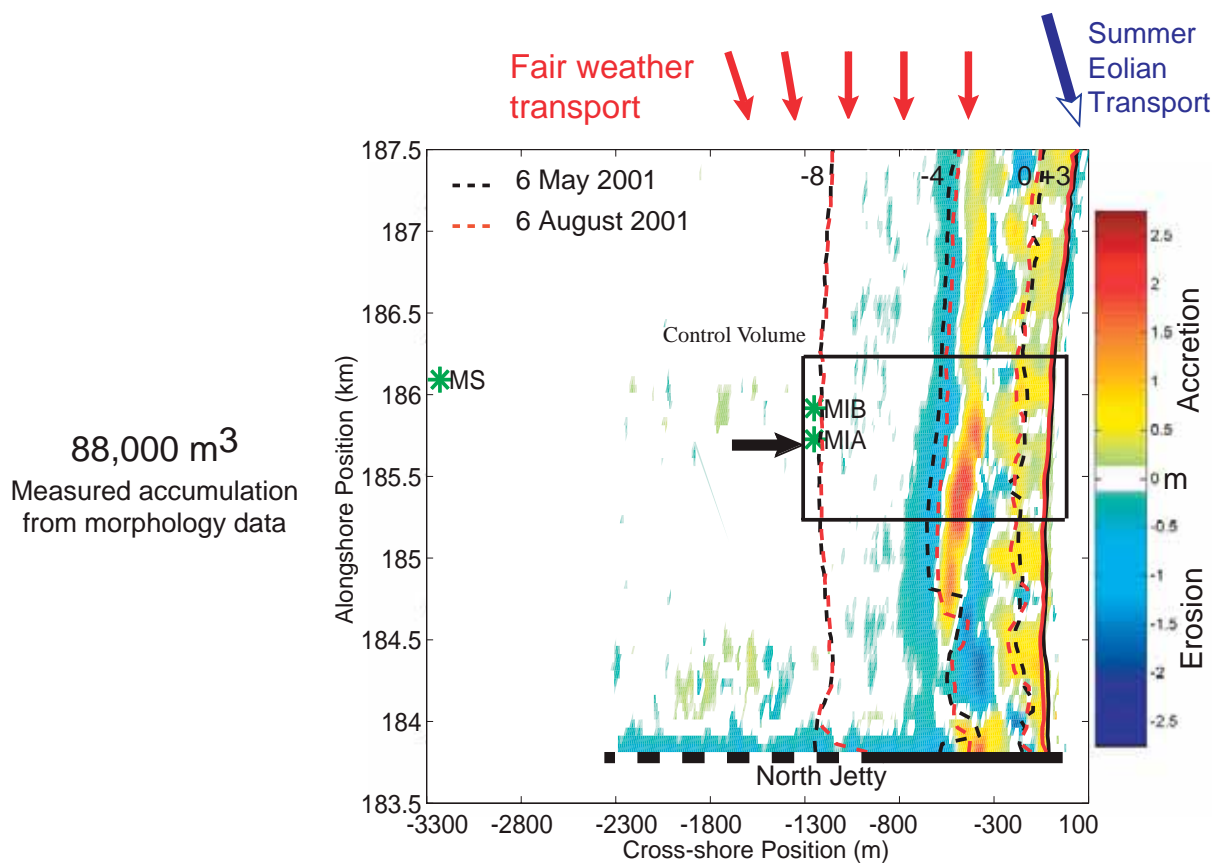


Figure 122. Nearshore planform differencing between the May and August surveys reveals that virtually all morphological change occurred between the -6 m and +3 m (MLLW—mean lower low water) contours. Alternating alongshore regions of erosion (indicated by cool colors) and accretion (warm colors) illustrate the predominantly 2-dimensional nature of the bathymetric changes.

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APPENDIX A. CHECK-OUT SHEETS

The following pages contain the check-out sheets used during the deployment and retrieval of the tripods. Each check-out sheet consists of 2 pages, with the filename located in the lower left corner.

Experiment: _____ **Tripod Check-Out Sheet** Date (GMT): _____
 Deployment #: _____ Name: _____
 Site: _____ Deployment: _____ Retrieval: _____ Cruise ID: _____

Tripod Conditions/Comments: _____

ADVOcean Hydra System:

ADVOcean probe- S/N: _____ sensor height: _____ ADV Ocean Logger S/N: _____ x direction checked? _____
 Horiz Dist between ADV Ocean & Paros _____ cm Paros- S/N: _____ sensor height: _____
 OBS 1- S/N: _____ sensor height: _____ sheltered? _____ OBS 2- S/N: _____ sensor height: _____ sheltered? _____
 Retrieval condition: _____

ADP:

ADP - S/N: _____ sensor height: _____ Battery Canister S/N: _____ x direction checked? _____
 Retrieval condition: _____

ADVField Hydra System:

ADVField probe- S/N: _____ sensor height: _____ ADVF Logger S/N: _____ x direction checked? _____
 Horiz Dist between ADVF & Paros _____ cm Paros- S/N: _____ sensor height: _____
 OBS 1- S/N: _____ sensor height: _____ sheltered? _____ OBS 2- S/N: _____ sensor height: _____ sheltered? _____
 Microcat CTD- S/N: _____ sensor height: _____ Sync - Master: _____ Slave: _____ None: _____
 Retrieval condition: _____

ADVField Hydra System:

ADVField probe- S/N: _____ sensor height: _____ ADVF Logger S/N: _____ x direction checked? _____
 Horiz Dist between ADVF & Paros _____ cm Paros- S/N: _____ sensor height: _____
 OBS 1- S/N: _____ sensor height: _____ sheltered? _____ OBS 2- S/N: _____ sensor height: _____ sheltered? _____
 Microcat CTD- S/N: _____ sensor height: _____ Sync - Master: _____ Slave: _____ None: _____
 Retrieval condition: _____

PC-ADP Hydra System:

PCADP probe- S/N: _____ sensor height: _____ PCADP Logger S/N: _____ x direction checked? _____
 Horiz Dist between PCADP & Paros _____ cm Paros- S/N: _____ sensor height: _____
 OBS 1- S/N: _____ sensor height: _____ sheltered? _____ OBS 2- S/N: _____ sensor height: _____ sheltered? _____
 Microcat CTD- S/N: _____ sensor height: _____ Sync - Master: _____ Slave: _____ None: _____
 Retrieval condition: _____

ABS:

ABS Logger - S/N: _____ ABS Battery canister - S/N: _____
 ABS Transducer height (all 3 should be same!): _____ Synced with S/N? _____
 Retrieval condition: _____

Rotating Sonar:

Profile Sonar- S/N: _____ sensor height: _____ Fan Sonar- S/N: _____ sensor height: _____
 Sonar Logger S/N: _____ Battery Canister S/N: _____
 Retrieval condition: _____

Pinger:

Pinger S/N: _____ Frequency (kHz): _____ Retrieval condition: _____

Release System:

Benthos S/N: _____ Enable Code: _____ Release Code: _____ Transmit Freq: _____ Armed? _____

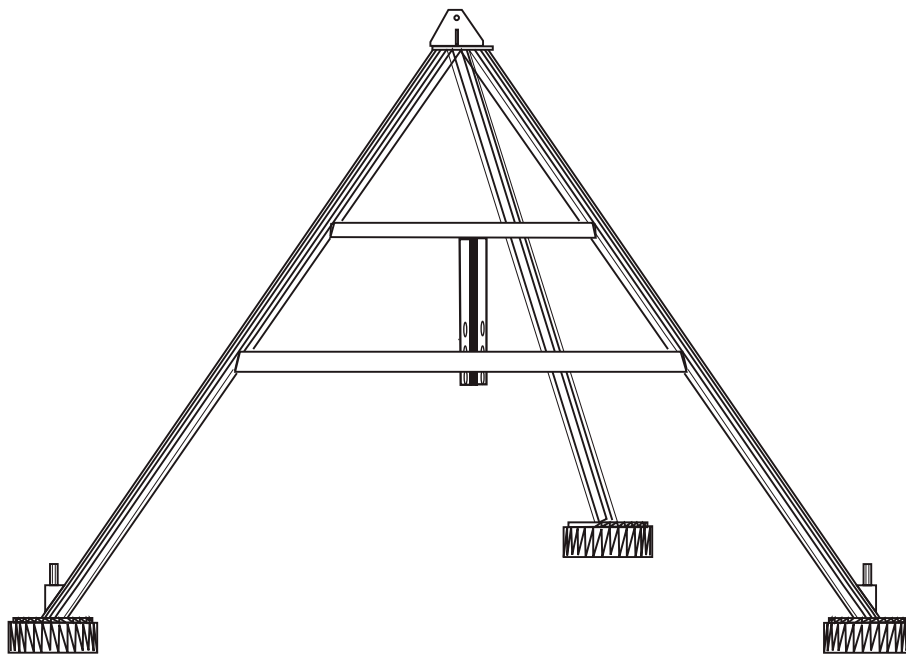
Figure 123. Tripod check-out sheet, page 1.

Rope Length in Canister (ft): _____

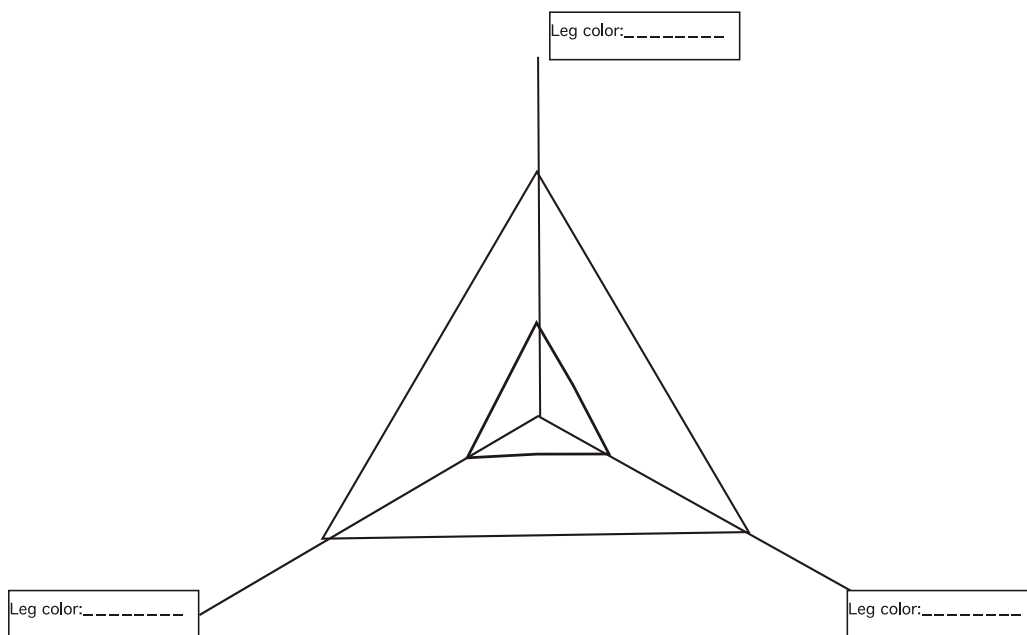
System Used upon Retrieval? _____

Retrieval condition: _____

Sketch all instruments. Note name, S/N, system (where applicable), and distance above bottom (units!) for sensor.



Remember to label color of legs on both sketches!



TripodCheckOut.doc
8/20/02

Figure 124. Tripod check-out sheet, page 2.

Experiment: _____ **SonTek ADV Check-Out Sheet** Date (GMT): _____
 Deployment #: _____ Name: _____
 Site: _____ Cruise ID: _____

Note: DO NOT POWER UP ADV WITH PROBE ON IT'S SIDE OR YOU WILL DAMAGE THE COMPASS!!!!

Instruments	Type	S/N	Elevation(cmab)
ADV Probe			
OBS1			
OBS2			
Paros Pressure			
Microcat			
Sync Cable			

Horizontal distance between ADV transducer and Paros _____ cm

Digital Photo: _____ Drawing of Insts: _____

_____ Sync watch and PC with GMT (7 6 726 7 6or 1-303-49971 11)

_____ Ensure that correct .drk file has been loaded for frequency Paros sensor (show Druck)
 (if applicable)

_____ 0) Set up **command file** in advance for deployment. Filename: _____ .cmd

- 1) Start computer & SonTerm
- 2) Connect external power to comm cable (ensure that sensor is vertical)
- 3) Connect RS-232, Alt-B to Break

_____ 4) Set logger clock and date (GMT) (7 6 726 7 6or 1-303-49971 11)

_____ 5) **Compass calibration** (Compcal -p1)

2 full circles, 1 min each, with lots of pitch/tilt

Compass Cal Results _____ / _____ / _____ (h/v/m) (e.g. 9/9/18.5)

Rating _____

_____ 6) **Start LOG FILE** (Alt-F) Filename: _____ .log

_____ 7) Check date, time & serial number with s conf and s system

_____ 8) **format** (clear the logger memory for new deployment)

_____ 9) Type the following commands in the Sonterm terminal emulator window (continuous output of sensors to screen) CNTL-C to stop

test

compass cont

Compass Heading _____ Check w/ handheld compass _____

parosfreq cont (ADV) or paros cont (ADV0) Pressure _____

_____ extsensor cont Do OBS check!

sensor cont (pressure will be 0, internal pressure not installed)

_____ while sensor cont is scrolling disconnect external power

Battery power is _____ Volts (Optimal is 18V) Temp _____

RE-CONNECT external power!!

_____ 10) comments (on "enter" will allow 3 lines of comments)

i.e.: USGS GHWEX2, First Deployment, Site XX (XXMaster or Slave? ?XX)

ADVX #XX at XXX cm, XX Paros S/N XX at XXX cm,

OBS1 # XXX at YY cm, OBS2 # XX at YY cm

_____ 11) **ALT-C** (to load command file set up in step 0) Filename: _____ .cmd .

_____ 12) **savesetup**

Figure 125. Acoustic Doppler velocimeter (ADV) Hydra system check-out sheet, page 1.

13) Using the following commands:

```
s conf
s system
s setup
s deploy
```

fill in the following table as appropriate. Be sure to **cross check the command file** to make sure that settings are correct.

	Actual	Example
S/N**		14:50:00
ExtPressureSensor*	Paros	2
OutFormat	ASCII	360C
OutMode	Polled	240C
Temp	12.	Yes
Sal	34.	Yes
TempMode	Measured	Yes
VelRange	3	Yes
CoordSystem	XYZ	Yes
SyncMode	Start	Yes
Deployment	M1B51	No
StartDate	2001/05/03	1200
		69698

* the command to change this to yes is: ExtPressureSensorInstalled set parosfreq

the command to change this to no is: ExtPressureSensorInstalled set no

** this is not a command

_____ 14) **saveSetup** - Save one more time just to be safe!!

_____ 15) **deploy**

Data will be recorded for _____ days

_____ 16) check start time

_____ 17) unplug comm cable from instrument

_____ 18) dummy in

_____ 19) close log file (alt-F) -- then move it to the directory you want it in

In Water(Date and Time and Time Zone): _____ On bottom: _____

Lat: _____ Long: _____ Datum: _____ Site Depth: _____ Nav. Method: _____

Miscellaneous comments:

Retrieval Notes:

Note: Synchronize Watch and PC with GMT (767-2676 or 1-303-499-7111)

Lat: _____ Long: _____ Datum: _____ Site Depth: _____ Nav. Method: _____

Start Log File (Alt-F) Filename: _____ .log

Time out of water: _____

Check Time: Actual: _____ vs. Logger: _____

Sensor cont Battery Voltage: _____

Compass Cont Heading: _____ Actual: _____

ExtSensor Cont Do OBS check!

parosfreq cont (ADVF) or paros cont (ADVO)

Files on recorder and File Size:

Comments:

Figure 126. Acoustic Doppler velocimeter (ADV) Hydra system check-out sheet, page 2.

Experiment: _____SonTek PC-ADP Check-Out Sheet Date (GMT): _____
 Deployment #: _____ Name: _____
 Site: _____ Cruise ID: _____

Note: If using Windows 2000, a **thick comm cable** must be used in order to load command file

Note: DO NOT Power-up PC-ADP sensor on it's side or you will DAMAGE THE COMPASS!!

Note: Pressure sensor must be mounted in line with PC-ADP probe head

Instruments	Type	S/N	Elevation (cmab)
PC-ADP Probe			
OBS1			
OBS2			
Paros Pressure			
Microcat			
Sync Cable			

Horizontal distance between PCADP transducer and Paros _____cm

Digital Photo: _____Drawing of Insts: _____

_____ Sync watch and PC with GMT (767-2676 or 1-303-499-7111)

_____ Ensure that correct .drk file has been loaded for frequency Paros sensor (show Druck)

_____ 0) Set up **command file** in advance for deployment. Filename: _____cmd

1) Start computer & SonTerm

2) Connect external power to comm cable (ensure that sensor is vertical)

3) Connect RS-232, Alt-B to Break

_____ 4) Set logger clock and date with GMT (767-2676 or 1-303-499-7111)

_____ 5) **Compass calibration** (Compcal -p1)

2 full circles, 1 min each, with lots of pitch/tilt

Compass Cal Results _____/_____/_____ (h/v/m) (e.g. 9/9/18.5)

Rating _____

_____ 6) **Start Log File** (Alt-F) Filename: _____log

_____ 7) Check date, time & serial number with s conf and s system

_____ 8) format (clear the logger memory for new deployment)

_____ 9) Type the following commands in the Sonterm terminal emulator window (continuous output of sensors to screen) CNTL-C to stop

test

compass cont

Compass Heading _____Check w/ handheld compass _____

parosfreq cont Pressure_____

extsensor cont Do OBS check!

_____ sensor cont (pressure will be 0, internal pressure not installed)

_____ while sensor cont is scrolling disconnect external power

Battery power is _____ Volts (Optimal is 18V) Temp_____

RE-CONNECT external power!!

10) comments (on "enter" will allow 3 lines of comments)

i.e.: USGS GHWEX2, First Deployment, Site XX (XXMaster or Slave? ?XX)

PC-ADP #XX at XXX cm, Freq Paros S/N XX at XXX cm,

OBS1 # XXX at YY cm, OBS2 # XX at YY cm

_____ 11) **ALT-C** (to load command file set up in step 0) Filename: _____cmd

_____ 12) **savesetup**

13) Using the following commands:

s conf

s system

s setup

s deploy

ResBlankDistance This checks the resolution blanking distance

fill in the following table as appropriate. Be sure to **cross check the**

command file to make sure that settings are correct.

Figure 127. Pulse-coherent acoustic Doppler profiler (PCADP) Hydra system check-out sheet, page 1.

	Actual	Example	A	ctual	Example
S/N**	H	40	Max Range** (m)	1	.12
OutFormat		ASCII	User Pulse Lag		2.07
OutMode		POLLED	PulseLag (m)		
Recorder		ON	System Lag** (m)	2	.11
RecMode		Normal	User Res Lag		0.47
SyncMode		Disable	ResPulseLag(m)		
PCMode		Yes	System Res Lag** (m)	0	.51
Temp		12	Deployment		A1H40
Sal		33.5	Startdate		2001/01/2
TempMode		MEASURED	2		
Cellsize (m)		.08	Starttime		09:30:00
BlankDistance (m)		.10	PingInterval		0
Ncells		11	BurstMode		ENABLED
AvgInterval		2	BurstInterval		600
ProfileInterval		2.	ProfilesPerBurst		256
CoordSystem		BEAM	Resolution Blanking		0.24
			Distance (m)		
			ResBlankDistance		

** this is not a command

---- 14) **SaveSetup** - Save one more time just to be safe!!

---- 15) **deploy**

User prf lag:----- Actual lag:-----

User res lag:----- Actual lag:-----

Data will be recorded for ----- days

---- 16) check start time

17) unplug comm cable at instrument

---- 18) dummy in

19) close log file (alt-F) -- then move it to the directory you want it in

In Water(Date and Time and Time Zone): ----- On bottom: -----

Lat:-----Long:-----Datum:-----Site Depth:-----Nav. Method:-----

Miscellaneous comments:

Retrieval Notes:

Note: Synchronize Watch and PC with GMT (767-2676 or 1-303-499-7111)

Lat:-----Long:-----Datum:-----Site Depth:-----Nav. Method:-----

Start Log File (Alt-F) Filename: -----_log

Time out of water: -----

Check Time: Actual:----- vs. Logger: -----

Sensor cont Battery Voltage:-----

Compass Cont Heading:-----Actual:-----

ExtSensor Cont Do OBS check!

parosfreq cont

Files on recorder and File Size:

Figure 128. Pulse-coherent acoustic Doppler profiler (PCADP) Hydra system check-out sheet, page 2.

Experiment: _____ **SonTek ADP Check-Out Sheet** Date (GMT): _____
 Deployment #: _____ Name: _____
 Site: _____ Cruise ID: _____

Note: DO NOT Power-up ADP sensor on it's side or you will DAMAGE THE COMPASS!!

Instruments	Type	S/N	Elevation (cmab)
ADP Sensor/Logger			

Digital Photo: _____ Drawing of Insts: _____

_____ Sync watch and PC with GMT (767-2676 or 1-303-499-7111)

_____ Ensure that correct .drk file has been loaded for Druck pressure sensor (show Druck)

_____ 0) Set up **command file** in advance for deployment. Filename: _____ .cmd

1) Start computer & SonTerm

2) Connect external power to comm cable (ensure that sensor is vertical)

3) Connect RS-232, Alt-B to Break

_____ 4) Set logger clock and date with GMT (767-2676 or 1-303-499-7111)

_____ 5) **Compass calibration** (Compcal -p1)

2 full circles, 1 min each, with lots of pitch/tilt

Compass Cal Results _____ / _____ / _____ (h/v/m) (e.g. 9/9/18.5)

Rating _____

_____ 6) **Start Log File** (Alt-F) Filename: _____ .log

_____ 7) Check date, time & serial number with s conf and s system

_____ 8) **format** (clear the logger memory for new deployment)

_____ 9) Type the following commands in the Sonterm terminal emulator window (continuous output of sensors to screen) CNTL-C to stop

test

compass cont

Compass Heading _____ Check w/ handheld compass _____

Druck Cont Pressure _____ Temp _____

sensor cont

_____ while sensor cont is scrolling disconnect external power

Battery power is _____ Volts (Optimal is 18V)

RE-CONNECT external power!!

10) comments _____ (on "enter" will allow 3 lines of comments)

i.e.: USGS GHWEX2, First Deployment,

Site XX

ADP #XX at XXX cm,

_____ 11) **ALT-C** (to load command file set up in step 0) Filename: _____ .cmd

_____ 12) **savesetup**

13) Using the following commands:

s conf

s system

s setup

s deploy

fill in the following table as appropriate. Be sure to **cross check the command file** to make sure that settings are correct.

Figure 129. Acoustic Doppler profiler (ADP) check-out sheet, page 1.

	Actual	Example
S/N**	C	134
External Pressure Sensor**		Druck
OutFormat		ASCII
OutMode		POLLED
Recorder		ON
RecMode		Normal
SyncMode		Disable
Temp		12
Sal		33.5
TempMode		MEASURED
Cellsize (m)		.5
BlankDistance (m)		.4
Ncells		65
AvgInterval		900
ProfileInterval		1800
PingInterval		0.0

** this is not a command

A	ctual	Example
CoordSystem		ENU
Deployment		M1134
StartDate		2001/01/22
StartTime		09:30:00
BurstMode		Disabled
RecordPSeries after how many profiles		2
PseriesRate (Hz)		2
PseriesLength (points)		4096
PseriesDuration		2048
OutPSeriesMode		Auto
User ResLag		.40
Sys ResLag		.41
MaxVertVel (m/s)		.94
MaxHorizVel (m/s)		2.22
MinCorrLevel (%)		25

---- 14) **SaveSetup** - Save one more time just to be safe!!

---- 15) **deploy**
 Data will be recorded for _____ days
 User Coh lag:_____ Actual Lag:_____

---- 16) check start time

 17) unplug comm cable at instrument

---- 18) dummy in

 19) close log file (alt-F) – then move it to the directory you want it in

In Water(Date and Time and Time Zone): _____ On bottom: _____

Lat:_____Long:_____Datum:_____Site Depth:_____Nav. Method:_____

Miscellaneous comments:

Retrieval Notes:

Note: Synchronize Watch and PC with GMT (767-2676 or 1-303-499-7111)

Lat:_____Long:_____Datum:_____Site Depth:_____Nav. Method:_____

Start Log File (Alt-F) Filename: _____log

Time out of water: _____

Check Time: Actual:_____ vs. Logger: _____

Sensor cont Battery Voltage:_____

Compass Cont Heading:_____Actual:_____

Druck Cont _____

Files on recorder and File Size:•

Comments:•

ADPCheckOut.doc

8

2

Figure 130. Acoustic Doppler profiler (ADP) check-out sheet, page 2.

Experiment: _____ **AquaTec ABS Check-Out Sheet**

Date (GMT): _____

Deployment #: _____

Name: _____

Site: _____

Cruise ID: _____

Note: Sampling starts one burst interval after you complete Step 8, so choose when to start this procedure accordingly.

----- Sync watch and PC with GMT (7 6 7 2 6 7 6 or 1-303-4997111)

0) Don't connect the sync cable to the ABS until step 11.

1) Start computer & AquaTalk

2) Connect external power to comm cable

3) Connect RS-232, click on **Connect** in the AquaTalk dialog box.

4) Click on **Logger Info**

a) Serial Number _____

b) Check that there is ample disk space for the deployment. If not, click on **Format Drive**. (Note that formatting (clearing) the disk is SLOW, this should be done ahead of time.)

----- c) **SET** logger time to PC time

5) Click on **Modify Regime**.

In the **Logger Parameters** dialog box set the following parameters and record values below.:

Parameter	A	ctual	Example
Frequencies			All three
Storage Resolution			16 bit
Mode			Fore
Gain			Low
Sample Rate, Hz			64
Samples/Average			64
Burst Duration			30 minutes
Logger Mode			Automatic
If logger mode = Auto: Inter Burst Time			60 minutes
If logger mode = Manual Trigger skip			N/A

In Manual Mode, the ABS only initiates sampling when triggered.

In Automatic Mode, the ABS will respond to a trigger, but if not triggered will sample according to the automatic schedule. For more details, see step 8.

Click **Next**

6) In **Bin Selection** dialog box, select bins for which you want to collect data.

Example: **Select all**

Click **Next**

7) **Logger date & time** dialog box: Time shown should be the same as PC time because of step 4 c, but if it isn't, **Correct Time**

Click **Next**

(over)

Figure 131. Acoustic backscatter system (ABS) check-out sheet, page 1.

8) Write Setup to Logger?

When you click OK, the logger will start the first burst interval (sampling starts at the beginning of the second interval). So **wait** until one burst interval before you want sampling to begin before you click OK (and record time below). The ABS will not respond to an auto-sampling burst start time which occurs during a triggered burst, or to a trigger received during an auto burst. Usually, the strategy is to set auto sampling to start after triggered sampling should start (and end before the next trigger), so that auto sampling serves as a back-up in case triggering fails. In determining lag between trigger and auto starts, allow for clock drift. The sync does not correct the ABS clock.

Example:

The ABS will be triggered at 10 minutes before the hour. You want automatic sampling to start on the hour, so click OK on the hour.

Time you clicked OK to write setup to logger: _____

Click Next

Note that there's a final dialog box saying *Begin logging*, but that's not correct, the first burst interval begins when you write setup to logger.

Click OK to finish setup wizard.

9) unplug comm cable at instrument

____ 10) comm dummy in

____] 1) After the SONTEK instruments are programmed, **connect the sync cable to the ABS**. (If you do it sooner, every deploy and savesetup will trigger the ABS, creating confusing files.)

In Water(Date and Time and Time Zone): _____ On bot tom: _____

Lat:_____ Long:_____ Datum:_____ Nav. Method:_____

Site depth_____

Comments:

Retrieval Notes:

Synchronize Watch and PC with GMT (7 6 7-26 7 6or 1-303-49 9-71 1 1)

Lat:_____ Long:_____ Datum:_____ Nav. Method:_____

Site Depth _____

Time out of water: _____

Check Time: Actual:_____ vs. Logger: _____

To stop further data collection:

_____ Change logger mode to Manual

_____ Disconnect sync cable

_____ Dummy sync cable port

Comments:

Figure 132. Acoustic backscatter system (ABS) check-out sheet, page 2.

APPENDIX B. FIELD LOG FROM PROCESSES EXPERIMENT

Deployment 1:

5/4/01 - Waves from west, 6-10 ft. Little wind. Good visibility. By 2:45pm PST the weather has markedly gotten worse. Shorter period large waves and very choppy. While deploying the tripod at Site SD, one of the OBS may have hit the side of the boat and twisted a bit.

Retrieval 1 - 6/5/01:

Overcast, not much wind. Waves less than a meter out of the south/southwest. Communicated with instruments after returning all 6 tripods to the marina.

MIA: Rope to buoy was wrapped under the tripod and hooked around ADVF 231 and Paros S/N 70136 (PCADP). Upon retrieval found sensor arm to ADVF 231 was broken off at bottom of pressure casing (fig. 133). The break looks fresh. No corrosion on electronics. The mounting arm for ADVF 231 is bent towards the red leg approximately 45 degrees (fig. 134). The tripod frame crossbar directly next to 231 is also bent upwards. The connector to Paros 70136 is exposed. It looks like the cable connector, including locking ring, was pulled off during recovery. Pins on the Paros were bent inwards toward the center mounting bar. ADVF 244 appears to be OK but the bar that it is mounted on is bent in towards the center of the tripod approximately 30 degrees. The center bar, which is the Paros mount, is bent approximately 5 degrees towards the red leg. The corner of the bottom platform where ADVF 244 is mounted is bent downwards. All other instruments appear to be structurally ok. Almost everything is covered with barnacles and a red stringy algae or bryozoan. The OBS, ADVs, PCADP and ABS transducers and receivers all have some biofouling on them. The transducer paint is gone from two of the PCADP transducers. Nothing appears to be growing on the feet and legs of the tripod to about a height of one foot. Tripod might have fell on its side on top of the rope or in the waves of a storm the rope may have gotten pulled down and caught on the tripod.

MIB: Pulled up easily. Looks like it was buried about a foot based upon the biofouling on the legs. Everything appears to be structurally sound. Everything is covered in barnacles and a red stringy algae or bryozoan including the ADV and sonar transducers and receivers and OBS faces. After one hour we have not yet seen the sonar rotate. There is much growth on it and a worn area is can be seen around the rotating parts.

SD: Pulled off bottom very easily. Barnacles are actually growing on the feet of the red and blue legs, suggesting they were buried only about 4 inches. Much less growth on tripod. Slight film present on ADP and ADV transducers and receivers. Algae and barnacles on rest of tripod. Everything appears to be structurally ok. The two OBS appear to be OK but turned toward the leg, may be seeing the leg. Some barnacles and algae are growing on the faces of the OBS. The tie wrap from OBS 1428 appears to be missing or the end is broken off. A lot of sediment was rushing out of the rope canister after pulling the tripod. Can see about 3/4 cm of sediment inside top crossbars.

MS: Tripod pulled up fairly easily, buried approximately one foot. Some algae and barnacles all over tripod and instruments including transducers and receivers. One band clamp was broken on the ABS battery case; it broke recently.

MD: Some algae, barnacles and egg pods growing on tripod and instruments including transducers and receivers. Tripod pulled off bottom easily. Buried to plate on foot. Sediment laden water poured out of tripod upon retrieval. Lower OBS has twisted and appears to be partially looking towards leg. One band clamp is broken on the ADV0 battery case; it did not break very recently. Small crab came up with tripod.

ND: Pulled off bottom easily. Barnacles are present on rubber pad between lead foot and plate on foot. Sediment laden water poured out of the tripod when retrieving. Algae, barnacles, and egg pods on tripod and instruments including transducers and receivers. Small crab spotted crawling on OBS upon retrieval. Small octopus pulled up with tripod.



Figure 133. Photograph showing the damage done to acoustic Doppler Field velocimeter (ADVF), serial number 231, during Retrieval 1.

Retrieval 2 7/11/01:

ND: Lots of sediment pouring out of rope canister and tripod. Some barnacles, algae, and egg pods on tripod. OBS have a little algae growing on their faces. ADV and ADP sensors have minimal biofouling. Tripod appears to be in good condition. Jellyfish seen in area. After the tripod was sitting on the deck, sediment was still coming out of the tripod. Checked sediment and it appeared to be much finer than sand from this area, more silt and less sand.

MD: Slightly more barnacles and algae than at ND. OBS have some algae and small barnacles. ADV sensors have little to no biofouling. ADP sensors have some small barnacles growing on them. Sediment poured out of tripod and rope canister while pulling tripod out of the water. There are some egg pods growing on the tripod. Other than biofouling, the tripod appears to be in great condition.

SD: Lots of sediment pouring out of the tripod and rope canister. Less biofouling than ND or MD. Has few small barnacles and some algae. Little to no algae on ADV sensors. Little



Figure 134. Photograph showing the damage done to the tripod from Site MIA during Retrieval 1.

algae on ADP sensors. OBS have some algae growing on sensors. Other than biofouling, the tripod appears to be in great condition.

MIA: Lots of biofouling, algae and barnacles. Other than biofouling the tripod appears to be in good condition. OBS sensors have barnacles and algae growing on them. ABS, PCADP and ADVF all have some barnacles and algae growing on them. Appears to have been buried approximately 10 inches.

MIB: Lots of sediment pouring out of tripod when pulled out of the water. Tons! of biofouling, especially barnacles and algae. ADV sensors have a lot of barnacles and algae (fig. 135). Appears to have been buried to about the height of the foot. Sonar sensors appear to have not moved in awhile because of barnacle growth. Entirety of the sonar instruments are encrusted with barnacles (fig. 136). OBS sensors appear to be almost entirely covered with barnacles. ADV sensors have a lot of barnacles and algae growing on them. Other than biofouling, the tripod appears to be in good condition.

MS: Sediment is pouring out of tripod upon removal from water. Much biofouling, algae and barnacles, but otherwise the tripod appears to be in good condition. OBS have a good amount of barnacles growing on them. ADV sensors have some barnacles and algae growing on them. ABS sensors have a small amount of barnacles on them. Appears to have been buried to about the foot.



Figure 135. Photograph showing the amount of biofouling on the ADV0 at Site MIB after Deployment 2.



Figure 136. Photograph showing the biofouling on the profiling sonar after Deployment 2 at Site MIB.

APPENDIX C. DESCRIPTION OF FILES ON DVDS AND CONTENTS OF COMPRESSED FILES

Tables 33 and 34 list the files contained on the two DVDs provided with this report. Many files are provided in a .zip format. The contents of the .zip files are described in table 35. File sizes are provided.

All m-files provided with this report are provided as a courtesy to the user. The validity and usability of the m-files are in no way guaranteed by USGS, the authors of the report, or the creators of the m-files. Any person or entity that relies on information generated by or derived from these m-files does so at their own risk.

Table 33. Contents of DVD01.

Path	Filename	Contents	File Size
	1_README.txt	DVD information and instructions	3 KB
	INDEX.htm	HTML page with links to data files	12 KB
	DSXX.pdf	PDF version of paper report	42 MB
	CDConTb.htm	index.htm support file	35 KB
	Site_Map.htm	index.htm support file	3 KB
	Dep_Tabl.htm	index.htm support file	20 KB
	Default.css	index.htm support file	1 KB
images	Banner.jpg	index.htm support file	30 KB
images	Banner2.jpg	index.htm support file	14 KB
images	DepTb_Sm.jpg	index.htm support file	4 KB
images	DepTb_Sm.png	index.htm support file	8 KB
images	GH_Site.gif	index.htm support file	80 KB
images	GHST_sm.gif	index.htm support file	8 KB
images	Icon_Table.gif	index.htm support file	7 KB
images	OFCvr_Sm.gif	index.htm support file	6 KB
ProcessesExperiment\ND01	nd-adp-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\ND01	nd-adp-d01.zip	ADP data converted to ASCII files - zipped	560 KB
ProcessesExperiment\ND01	nd-advo-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\ND01	nd-advo-d01.zip	ADVO data converted to ASCII files - zipped	55 KB
ProcessesExperiment\ND02	nd-adp-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\ND02	nd-adp-d02.zip	ADP data converted to ASCII files - zipped	599 KB
ProcessesExperiment\ND02	nd-advo-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\ND02	nd-advo-d02.zip	ADVO data converted to ASCII files - zipped	55 KB
ProcessesExperiment\MD01	md-adp-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MD01	md-adp-d01.zip	ADP data converted to ASCII files - zipped	584 KB
ProcessesExperiment\MD01	md-advo-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MD01	md-advo-d01.zip	ADVO data converted to ASCII files - zipped	54 KB
ProcessesExperiment\MD02	md-adp-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MD02	md-adp-d02.zip	ADP data converted to ASCII files - zipped	589 KB
ProcessesExperiment\MD02	md-advo-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MD02	md-advo-d02.zip	ADVO data converted to ASCII files - zipped	56 KB
ProcessesExperiment\MS01	ms-advo-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MS01	ms-advo-d01.zip	ADVO data converted to ASCII files - zipped	54 KB
ProcessesExperiment\MS01	ms-abs-d01.txt	Directory of similarly named .zip file	2 KB
ProcessesExperiment\MS01	ms-abs-d01_week1.zip	Binary ABS Files for a week long period - zipped	191 MB
ProcessesExperiment\MS01	ms-abs-d01_week2.zip	Binary ABS Files for a week long period - zipped	212 MB
ProcessesExperiment\MS01	ms-abs-d01_week3.zip	Binary ABS Files for a week long period - zipped	215 MB
ProcessesExperiment\MS01	ms-abs-d01_week4.zip	Binary ABS Files for a week long period - zipped	211 MB
ProcessesExperiment\MS01	ms-abs-d01_week5.zip	Binary ABS Files for a week long period - zipped	148 MB
ProcessesExperiment\MS02	ms-advo-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MS02	ms-advo-d02.zip	ADVO data converted to ASCII files - zipped	56 KB
ProcessesExperiment\MS02	ms-abs-d02.txt	Directory of similarly named .zip file	2 KB

Table 33. Contents of DVD01—Continued.

Path	Filename	Contents	File Size
ProcessesExperiment\MS02	ms-abs-d02_week1.zip	Binary ABS Files for a week long period - zipped	183 MB
ProcessesExperiment\MS02	ms-abs-d02_week2.zip	Binary ABS Files for a week long period - zipped	208 MB
ProcessesExperiment\MS02	ms-abs-d02_week3.zip	Binary ABS Files for a week long period - zipped	211 MB
ProcessesExperiment\MS02	ms-abs-d02_week4.zip	Binary ABS Files for a week long period - zipped	207 MB
ProcessesExperiment\MS02	ms-abs-d02_week5.zip	Binary ABS Files for a week long period - zipped	210 MB
ProcessesExperiment\MIA01	mia-advf231-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIA01	mia-advf231-d01.zip	ADVF data converted to ASCII files - zipped	33 KB
ProcessesExperiment\MIA01	mia-advf244-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIA01	mia-advf244-d01.zip	ADVF data converted to ASCII files - zipped	33 KB
ProcessesExperiment\MIA01	mia-pcadp-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIA01	mia-pcadp-d01.zip	PCADP data converted to ASCII files - zipped	49 KB
ProcessesExperiment\MIA01	mia-abs.d01.txt	Directory of similarly named .zip file	11 KB
ProcessesExperiment\MIA01	mia-abs-d01_week1.zip	Binary ABS Files for a week long period - zipped	192 MB
ProcessesExperiment\MIA01	mia-abs-d01_week2.zip	Binary ABS Files for a week long period - zipped	209 MB
ProcessesExperiment\MIA01	mia-abs-d01_week3.zip	Binary ABS Files for a week long period - zipped	208 MB
ProcessesExperiment\MIA01	mia-abs-d01_week4.zip	Binary ABS Files for a week long period - zipped	204 MB
ProcessesExperiment\MIA01	mia-abs-d01_week5.zip	Binary ABS Files for a week long period - zipped	137 MB
ProcessesExperiment\MIA02	mia-advf244-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIA02	mia-advf244-d02.zip	ADVF data converted to ASCII files - zipped	66 KB
ProcessesExperiment\MIA02	mia-pcadp-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIA02	mia-pcadp-d02.zip	PCADP data converted to ASCII files - zipped	52 KB
ProcessesExperiment\MIA02	mia-abs-d02.txt	Directory of similarly named .zip file	2 KB
ProcessesExperiment\MIA02	mia-abs-d02_week1.zip	Binary ABS Files for a week long period - zipped	168 MB
ProcessesExperiment\MIA02	mia-abs-d02_week2.zip	Binary ABS Files for a week long period - zipped	202 MB
ProcessesExperiment\MIA02	mia-abs-d02_week3.zip	Binary ABS Files for a week long period - zipped	206 MB
ProcessesExperiment\MIA02	mia-abs-d02_week4.zip	Binary ABS Files for a week long period - zipped	205 MB
ProcessesExperiment\MIA02	mia-abs-d02_week5.zip	Binary ABS Files for a week long period - zipped	206 MB
ProcessesExperiment\MIB01	mib-adv0-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIB01	mib-adv0-d01.zip	ADV0 data converted to ASCII files - zipped	55 KB
ProcessesExperiment\MIB01	mib-sonar_may.avi	Sonar movie - May 2001 data	15 MB
ProcessesExperiment\MIB02	mib-adv0-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\MIB02	mib-adv0-d02.zip	ADV0 data converted to ASCII files - zipped	56 KB
ProcessesExperiment\MIB02	mib-sonar_june.avi	Sonar movie - June 2001 data	14 MB
ProcessesExperiment\SD01	sd-adp-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\SD01	sd-adp-d01.zip	ADP data converted to ASCII files - zipped	572 KB
ProcessesExperiment\SD01	sd-adv0-d01.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\SD01	sd-adv0-d01.zip	ADV0 data converted to ASCII files - zipped	51 KB
ProcessesExperiment\SD02	sd-adp-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\SD02	sd-adp-d02.zip	ADP data converted to ASCII files - zipped	614 KB
ProcessesExperiment\SD02	sd-adp-d02.txt	Directory of similarly named .zip file	1 KB
ProcessesExperiment\SD02	sd-adv0-d02.zip	ADV0 data converted to ASCII files - zipped	53 KB
Morphology	data_0329.txt	Raw and processed data collected on or about 03/29/01	1 KB
Morphology	data_0329.zip	Directory of data_0329.zip	720 KB
Morphology	data_0506.txt	Raw and processed data collected on or about 05/06/01	1 KB
Morphology	data_0506.zip	Directory of data_0506.zip	2 MB
Morphology	data_0530.txt	Raw and processed data collected on or about 05/30/01	1 KB
Morphology	data_0530.zip	Directory of data_0530.zip	2 MB
Morphology	data_07079.txt	Raw and processed data collected on or about 07/07/01	1 KB
Morphology	data_0707.zip	Directory of data_0707.zip	2 MB
Morphology	data_0806.txt	Raw and processed data collected on or about 08/06/01	1 KB
Morphology	data_0806.zip	Directory of data_0806.zip	2 MB
Morphology	surface_maps.txt	Weekly surface maps, raw ASCII data	1 KB
Morphology	surface_maps.zip	Directory of surface_maps.txt	694 KB

Table 34. Contents of DVD02.

Path	Filename	Contents	File Size
	1_README.txt	DVD information and instructions	3 KB
	INDEX.htm	HTML page with links to data files	12 KB
	DSXX.pdf	PDF version of paper report	40 MB
	B1_Blue&Green_7.5.jpg	index.htm support file	108 KB
	Banner.jpg	index.htm support file	30 KB
	CDConTb.htm	index.htm support file	61 KB
	Default.css	index.htm support file	1 KB
	Dep_Tabl.htm	index.htm support file	25 KB
	DepTb_Sm.jpg	index.htm support file	3 KB
	DepTb_Sm.png	index.htm support file	8 KB
	GH_Site.gif	index.htm support file	80 KB
	GHST_sm.gif	index.htm support file	8 KB
	OFCvr_Sm.gif	index.htm support file	5 KB
	On-DVD01.htm	index.htm support file	1 KB
	On-DVD02.htm	index.htm support file	1 KB
	Site_Map.htm	index.htm support file	2 KB
ProcessesExperiment\Deployment1\BinaryFiles	md-adp-d01.adp	Raw binary data file	1 MB
ProcessesExperiment\Deployment1\BinaryFiles	md-advo-d01.adr	Raw binary data file	54 MB
ProcessesExperiment\Deployment1\BinaryFiles	mia-advf231d01.adr	Raw binary data file	270 MB
ProcessesExperiment\Deployment1\BinaryFiles	mia-advf244-d01.adr	Raw binary data file	271 MB
ProcessesExperiment\Deployment1\BinaryFiles	mia-pcadp-d01.adp	Raw binary data file	223 MB
ProcessesExperiment\Deployment1\BinaryFiles	mib-advo-d01.adr	Raw binary data file	54 MB
ProcessesExperiment\Deployment1\BinaryFiles	ms-advo-d01.adr	Raw binary data file	54 MB
ProcessesExperiment\Deployment1\BinaryFiles	nd-adp-d01.adp	Raw binary data file	16 MB
ProcessesExperiment\Deployment1\BinaryFiles	nd-advo-d01.adr	Raw binary data file	54 MB
ProcessesExperiment\Deployment1\BinaryFiles	sd-adp-d01.adp	Raw binary data file	16 MB
ProcessesExperiment\Deployment1\BinaryFiles	sd-advo-d01.adr	Raw binary data file	54 MB
ProcessesExperiment\Deployment2\BinaryFiles	md-adp-d02.adp	Raw binary data file	1 MB
ProcessesExperiment\Deployment2\BinaryFiles	md-advo-d02.adr	Raw binary data file	60 MB
ProcessesExperiment\Deployment2\BinaryFiles	mia-advf244-d02.adr	Raw binary data file	284 MB
ProcessesExperiment\Deployment2\BinaryFiles	mia-pcadp-d02.adp	Raw binary data file	233 MB
ProcessesExperiment\Deployment2\BinaryFiles	mib-advo-d02.adr	Raw binary data file	57 MB
ProcessesExperiment\Deployment2\BinaryFiles	ms-advo-d02.adr	Raw binary data file	57 MB
ProcessesExperiment\Deployment2\BinaryFiles	nd-adp-d02.adp	Raw binary data file	17 MB
ProcessesExperiment\Deployment2\BinaryFiles	nd-advo-d02.adr	Raw binary data file	58 MB
ProcessesExperiment\Deployment2\BinaryFiles	sd-adp-d02.adp	Raw binary data file	17 MB
ProcessesExperiment\Deployment2\BinaryFiles	sd-advo-d02.adr	Raw binary data file	59 MB
ProcessesExperiment\CalibrationFiles	958200.drk	Pressure sensor calibration file	1 KB
ProcessesExperiment\CalibrationFiles	995410.drk	Pressure sensor calibration file	1 KB
ProcessesExperiment\CalibrationFiles	P70136.drk	Pressure sensor calibration file	1 KB
ProcessesExperiment\CalibrationFiles	T60005.drk	Pressure sensor calibration file	1 KB
ProcessesExperiment\CalibrationFiles	T60006.drk	Pressure sensor calibration file	1 KB
ProcessesExperiment\CalibrationFiles	T66917.drk	Pressure sensor calibration file	1 KB
matlab_mfiles\ABS	LoadABS.m	M-file which reads the binary ABS files in to Matlab	5 KB

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files.

.zip Filename	Contents	Unpacked File Size (bytes)
nd-adp-d01.zip	nd-adp-d01.ctf	4306
	nd-adp-d01.hdr	190076
	nd-adp-d01.ve	822624
	nd-adp-d01.vn	822624
	nd-adp-d01.vu	822624
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
nd-advo-d01.zip	nd-advo-d1.ctf	2491
	nd-advo-d01.hdr	242262
	adv-hdr-fmt.txt	2359
nd-adp-d02.zip	nd-adp-d02.ctf	4305
	nd-adp-d02.hdr	203130
	nd-adp-d02.ve	879120
	nd-adp-d02.vn	879120
	nd-adp-d02.vu	879120
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
nd-advo-d02.zip	nd-advo-d02.ctf	2472
	nd-advo-d02.hdr	259897
	adv-hdr-fmt.txt	2359
md-adp-d01.zip	md-adp-d01.ctf	3927
	md-adp-d01.hdr	203008
	md-adp-d01.ve	878592
	md-adp-d01.vn	878592
	md-adp-d01.vu	878592
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
md-advo-d01.zip	md-advo-d01.ctf	2491
	md-advo-d01.hdr	242262
	adv-hdr-fmt.txt	2359
md-adp-d02.zip	md-adp-d02.ctf	3927
	md-adp-d02.hdr	203008
	md-adp-d02.ve	878592
	md-adp-d02.vn	878592
	md-adp-d02.vu	878592
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
md-advo-d02.zip	md-advo-d02.ctf	2492
	md-advo-d02.hdr	260416
	adv-hdr-fmt.txt	2359
ms-advo-d01.zip	ms-advo-d01.ctf	2519
	ms-advo-d01.hdr	241636
	adv-hdr-fmt.txt	2359
ms-abs-d01_week1.zip	week1\20010504194507.aqa	1393352
	week1\20010504204507.aqa	1393352
	...file names continue at hourly intervals through to...	
	week1\20010510224507.aqa	1393352
	week1\20010510234507.aqa	1393352
total of 149 files with total volume of		207609448

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
ms-abs-d01_week2.zip	week2\20010511004507.aqa	1393352
	week2\20010511014507.aqa	1393352
	...file names continue at hourly intervals through to...	
	week2\20010517224507.aqa	1393352
	week2\20010517234507.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d01_week3.zip	week3\20010518004507.aqa	1393352
	week3\20010518014507.aqa	1393352
	...file names continue at hourly intervals through to...	
	week3\20010524224507.aqa	1393352
	week3\20010524234507.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d01_week4.zip	week4\20010525004507.aqa	1393352
	week4\20010525014507.aqa	1393352
	...file names continue at hourly intervals through to...	
	week4\20010531224507.aqa	1393352
	week4\20010531234507.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d01_week5.zip	week5\20010601004507.aqa	1393352
	week5\20010601014507.aqa	1393352
	...file names continue at hourly intervals through to...	
	week5\20010605214507.aqa	1393352
	week5\20010605224507.aqa	1129418
	total of 119 files with total volume of	165544954
ms-advo-d02.zip	ms-advo-d02.ctl	2489
	ms-advo-d02.hdr	256660
	adv-hdr-fmt.txt	2359
ms-abs-d02_week1.zip	week1\20010607194010.aqa	1393352
	week1\20010607204010.aqa	1393352
	...file names continue at hourly intervals through to...	
	week1\20010613224010.aqa	1393352
	week1\20010613234010.aqa	1393352
	total of 149 files with total volume of	207609448
ms-abs-d02_week2.zip	week2\20010614004010.aqa	1393352
	week2\20010614014010.aqa	1393352
	...file names continue at hourly intervals through to...	
	week2\20010620224010.aqa	1393352
	week2\20010620234010.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d02_week3.zip	week3\20010621004010.aqa	1393352
	week3\20010621014010.aqa	1393352
	...file names continue at hourly intervals through to...	
	week3\20010627224010.aqa	1393352
	week3\20010627234010.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d02_week4.zip	week4\20010628004010.aqa	1393352
	week4\20010628014010.aqa	1393352
	...file names continue at hourly intervals through to...	
	week4\20010704224010.aqa	1393352
	week4\20010704234010.aqa	1393352
	total of 168 files with total volume of	234083136
ms-abs-d02_week5.zip	week5\20010705004010.aqa	1393352
	week5\20010705014010.aqa	1393352
	...file names continue at hourly intervals through to...	
	week5\20010711214010.aqa	1393352
	week5\20010711224010.aqa	1393352
	total of 167 files with total volume of	232689784

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued

.zip Filename	Contents	Unpacked File Size (bytes)
mia-advf231-d01.zip	mia-advf231-d01.ctf	2498
	mia-advf231-d01.hdr	130267
	adv-hdr-fmt.txt	2359
mia-advf244-d01.zip	mia-advf244-d01.ctf	2503
	mia-advf244-d01.hdr	130216
	adv-hdr-fmt.txt	2359
mia-pcadp-d01.zip	mia-pcadp-d01.ctf	3371
	mia-pcadp-d01-bm.txt	222241
	mia-pcadp-fmt.txt	830
mia-abs-d01_week1.zip	week1\20010504080011.aqa	1393352
	week1\20010504090011.aqa	1393352
	week1\20010504100011.aqa	1393352
	week1\20010504110011.aqa	1393352
	week1\20010504120011.aqa	1393352
	week1\20010504125009.aqf	1393352
	week1\20010504145009.aqf	1393352
	... continues bi-hourly through	
	week1\20010505045009.aqf	1393352
	week1\20010505065010.aqf	1393352
	... continues bi-hourly through	
	week1\20010505165010.aqf	1393352
	week1\20010505185019.aqf	1393352
	week1\20010505205010.aqf	1393352
	week1\20010505225019.aqf	1393352
	week1\20010506005011.aqf	1393352
	... continues bi-hourly through	
	week1\20010506085011.aqf	1393352
	week1\20010506105020.aqf	1393352
	week1\20010506125012.aqf	1393352
	... continues bi-hourly through	
	week1\20010507025012.aqf	1393352
	week1\20010507045013.aqf	1393352
	... continues bi-hourly through	
	week1\20010507165013.aqf	1393352
	week1\20010507205014.aqf	1393352
	... continues bi-hourly through	
	week1\20010508085014.aqf	1393352
	week1\20010508105015.aqf	1393352
	... continues bi-hourly through	
	week1\20010508205015.aqf	1393352
	week1\20010508225016.aqf	1393352
	... continues bi-hourly through	
	week1\20010509165016.aqf	1393352
	week1\20010509185017.aqf	1393352
	... continues bi-hourly through	
	week1\20010510045017.aqf	1393352
	week1\20010510065018.aqf	1393352
	... continues bi-hourly through	
	week1\20010510225018.aqf	1393352
	week1\20010504140011.aqa	1393352
	... continues bi-hourly through	
	week1\20010510220011.aqa	1393352
	total of 158 files with total volume of	220149616
mia-abs-d01_week2.zip	week2\20010511005018.aqf	1393352
	week2\20010511025019.aqf	1393352
	... continues bi-hourly through	
	week2\20010511165019.aqf	1393352
	week2\20010511185020.aqf	1393352

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	week2\20010511205020.aqf	1393352
	week2\20010511225020.aqf	1393352
	week2\20010512005056.aqf	1393352
	week2\20010512025020.aqf	1393352
	week2\20010512045038.aqf	1393352
	week2\20010512065020.aqf	1393352
	week2\20010512085021.aqf	1393352
	... continues bi-hourly through	
	week2\20010512165021.aqf	1393352
	week2\20010512185022.aqf	1393352
	week2\20010512205022.aqf	1393352
	week2\20010512225021.aqf	1393352
	week2\20010513005022.aqf	1393352
	... continues bi-hourly through	
	week2\20010513125022.aqf	1393352
	week2\20010513145023.aqf	1393352
	week2\20010513165032.aqf	1393352
	week2\20010513185023.aqf	1393352
	week2\20010513205032.aqf	1393352
	week2\20010513225032.aqf	1393352
	week2\20010514025023.aqf	1393352
	week2\20010514045023.aqf	1393352
	week2\20010514065023.aqf	1393352
	week2\20010514085033.aqf	1393352
	week2\20010514105033.aqf	1393352
	week2\20010514125024.aqf	1393352
	week2\20010504145024.aqf	1393352
	week2\20010514165024.aqf	1393352
	week2\20010514185024.aqf	1393352
	week2\20010514205025.aqf	1393352
	week2\20010514225024.aqf	1393352
	week2\20010515005025.aqf	1393352
	week2\20010515025025.aqf	1393352
	week2\20010515045025.aqf	1393352
	week2\20010515065025.aqf	1393352
	week2\20010515085043.aqf	1393352
	week2\20010515105025.aqf	1393352
	week2\20010515125026.aqf	1393352
	week2\20010515145035.aqf	1393352
	week2\20010515165026.aqf	1393352
	week2\20010515185044.aqf	1393352
	week2\20010515205026.aqf	1393352
	week2\20010515225026.aqf	1393352
	week2\20010516005044.aqf	1393352
	week2\20010516025026.aqf	1393352
	week2\20010516045027.aqf	1393352
	... continues bi-hourly through	
	week2\20010516105027.aqf	1393352
	week2\20010516125036.aqf	1393352
	week2\20010516145027.aqf	1393352
	week2\20010516165027.aqf	1393352
	week2\20010516185027.aqf	1393352
	week2\20010516225028.aqf	1393352
	week2\20010517005028.aqf	1393352
	week2\20010517025028.aqf	1393352
	week2\20010517045028.aqf	1393352
	week2\20010517065028.aqf	1393352
	week2\20010517085030.aqf	1393352

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
mia-abs-d01_week3.zip	week2\20010517105029.aqf	1393352
	week2\20010517125029.aqf	1393352
	week2\20010517145029.aqf	1393352
	week2\20010517165029.aqf	1393352
	week2\20010517185029.aqf	1393352
	week2\20010517205029.aqf	1393352
	week2\20010517225029.aqf	1393352
	week2\20010511000011.aqa	1393352
	... continues bi-hourly through	
	week2\20010517220011.aqa	1393352
	total of 166 files with total volume of	231296432
	week3\20010518005029.aqf	1393352
	week3\20010518025029.aqf	1393352
	week3\20010518045030.aqf	1393352
	... continues bi-hourly through	
	week3\20010518145030.aqf	1393352
mia-abs-d01_week3.zip	week3\20010518165031.aqf	1393352
	week3\20010518185030.aqf	1393352
	week3\20010518205031.aqf	1393352
	... continues bi-hourly through	
	week3\20010519045031.aqf	1393352
	week3\20010519065032.aqf	1393352
	week3\20010519085031.aqf	1393352
	week3\20010519105031.aqf	1393352
	week3\20010519125032.aqf	1393352
	... continues bi-hourly through	
	week3\20010519225032.aqf	1393352
	week3\20010520005033.aqf	1393352
	week3\20010520025033.aqf	1393352
	week3\20010520045042.aqf	1393352
	week3\20010520065118.aqf	1393352
	week3\20010520085033.aqf	1393352
	week3\20010520105033.aqf	1393352
	week3\20010520125033.aqf	1393352
	week3\20010520145033.aqf	1393352
	week3\20010520165034.aqf	1393352
	... continues bi-hourly through	
	week3\20010521045034.aqf	1393352
	week3\20010521065035.aqf	1393352
	week3\20010521085035.aqf	1393352
	week3\20010521105035.aqf	1393352
	week3\20010521125044.aqf	1393352
	week3\20010521145035.aqf	1393352
	week3\20010521165035.aqf	1393352
	week3\20010521185035.aqf	1393352
	week3\20010521205035.aqf	1393352
	week3\20010521225036.aqf	1393352
	week3\20010522005036.aqf	1393352
	week3\20010522045045.aqf	1393352
	week3\20010522065045.aqf	1393352
	week3\20010522085045.aqf	1393352
	week3\20010522105036.aqf	1393352
	week3\20010522125036.aqf	1393352
	week3\20010522145037.aqf	1393352
	week3\20010522165037.aqf	1393352
	week3\20010522185046.aqf	1393352
	week3\20010522205037.aqf	1393352
	week3\20010522225037.aqf	1393352

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	week3\20010523005037.aqf	1393352
	week3\20010523025046.aqf	1393352
	week3\20010523045037.aqf	1393352
	week3\20010523065005.aqf	1393352
	week3\20010523085047.aqf	1393352
	week3\20010523105038.aqf	1393352
	week3\20010523125038.aqf	1393352
	week3\20010523145038.aqf	1393352
	week3\20010523165047.aqf	1393352
	week3\20010523185038.aqf	1393352
	week3\20010523205039.aqf	1393352
	... continues bi-hourly through	
	week3\20010524085039.aqf	1393352
	week3\20010524105040.aqf	1393352
	... continues bi-hourly through	
	week3\20010524225040.aqf	1393352
	week3\20010518000011.aqa	1393352
	... continues bi-hourly through	
	week3\20010524220011.aqa	1393352
	total of 167 files with total volume of	232689784
mia-abs-d01_week4.zip	week4\20010525005040.aqf	1393352
	week4\20010525025040.aqf	1393352
	week4\20010525045041.aqf	1393352
	... continues bi-hourly through	
	week4\20010525125041.aqf	1393352
	week4\20010525145050.aqf	1393352
	week4\20010525165041.aqf	1393352
	week4\20010525185042.aqf	1393352
	... continues bi-hourly through	
	week4\20010526085042.aqf	1393352
	week4\20010526105043.aqf	1393352
	week4\20010526145043.aqf	1393352
	week4\20010526165043.aqf	1393352
	week4\20010526185101.aqf	1393352
	week4\20010526205043.aqf	1393352
	week4\20010526225043.aqf	1393352
	week4\20010527005044.aqf	1393352
	week4\20010527025044.aqf	1393352
	week4\20010527045044.aqf	1393352
	week4\20010527105044.aqf	1393352
	week4\20010527125044.aqf	1393352
	week4\20010527145044.aqf	1393352
	week4\20010527165054.aqf	1393352
	week4\20010527185045.aqf	1393352
	week4\20010527205045.aqf	1393352
	week4\20010527225045.aqf	1393352
	week4\20010528005045.aqf	1393352
	week4\20010528025054.aqf	1393352
	week4\20010528045045.aqf	1393352
	week4\20010528065045.aqf	1393352
	week4\20010528085054.aqf	1393352
	week4\20010528105046.aqf	1393352
	week4\20010528125046.aqf	1393352
	week4\20010528145046.aqf	1393352
	week4\20010528165055.aqf	1393352
	week4\20010528185046.aqf	1393352
	week4\20010528205046.aqf	1393352
	week4\20010528225046.aqf	1393352

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	week4\20010529005046.aqf	1393352
	week4\20010529025047.aqf	1393352
	... continues bi-hourly through	
	week4\20010529145047.aqf	1393352
	week4\20010530165048.aqf	1393352
	week4\20010530185048.aqf	1393352
	week4\20010530205048.aqf	1393352
	week4\20010530225057.aqf	1393352
	week4\20010530005048.aqf	1393352
	week4\20010530025057.aqf	1393352
	week4\20010530045115.aqf	1393352
	week4\20010530065049.aqf	1393352
	week4\20010530085048.aqf	1393352
	week4\20010530105049.aqf	1393352
	... continues bi-hourly through	
	week4\20010530205034.aqf	1393352
	week4\20010530225050.aqf	1393352
	... continues bi-hourly through	
	week4\20010531125050.aqf	1393352
	week4\20010531145051.aqf	1393352
	... continues bi-hourly through	
	week4\20010531205051.aqf	1393352
	week4\20010531225100.aqf	1393352
	week4\20010525000011.aqa	1393352
	... continues bi-hourly through	
	week4\20010531220011.aqa	1393352
	total of 165 files with total volume of	229903080
mia-abs-d01_week5.zip	week5\20010601005100.aqf	1393352
	week5\20010601025051.aqf	1393352
	week5\20010601045052.aqf	1393352
	... continues bi-hourly through	
	week5\20010601825052.aqf	1393352
	week5\20010601205053.aqf	1393352
	week5\20010601225102.aqf	1393352
	week5\20010602005053.aqf	1393352
	week5\20010602025053.aqf	1393352
	week5\20010602045102.aqf	1393352
	week5\20010602065053.aqf	1393352
	week5\20010602085054.aqf	1393352
	... continues bi-hourly through	
	week5\20010602145054.aqf	1393352
	week5\20010602185054.aqf	1393352
	... continues bi-hourly through	
	week5\20010603005054.aqf	1393352
	week5\20010603025112.aqf	1393352
	week5\20010603045055.aqf	1393352
	... continues bi-hourly through	
	week5\20010603105055.aqf	1393352
	week5\20010603125104.aqf	1393352
	week5\20010603145055.aqf	1393352
	week5\20010603165055.aqf	1393352
	week5\20010603185056.aqf	1393352
	week5\20010603205056.aqf	1393352
	week5\20010604005050.aqf	1393352
	week5\20010604025056.aqf	1393352
	week5\20010604045056.aqf	1393352
	week5\20010604065105.aqf	1393352
	week5\20010604085057.aqf	1393352

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	week5\20010604105106.aqf	1393352
	week5\20010604125057.aqf	1393352
	... continues bi-hourly through	
	week5\20010604205057.aqf	1393352
	week5\20010604225058.aqf	1393352
	... continues bi-hourly through	
	week5\20010605085058.aqf	1393352
	week5\20010605125059.aqf	1393352
	week5\20010605145058.aqf	1393352
	week5\20010605165111.aqf	1393352
	week5\20010605185111.aqf	1393352
	week3\20010601000011.aqa	1393352
	... continues bi-hourly through	
	week3\20010605200011.aqa	1189790
	week3\20010605210011.aqa	1189790
	week3\20010605220011.aqa	1189790
	week3\20010605230011.aqa	1189790
	total of 117 files with total volume of	162818622
mia-advf244-d02.zip	mia-advf244-d02.ctl	2491
	mia-advf244-d02.hdr	274186
	adv-hdr-fmt.txt	2359
mia-pcadp-d02.zip	mia-pcadp-d02.ctl	3381
	mia-pcadp-d02-bm.txt	234090
	mia-pcadp-fmt.txt	830
mia-abs-d02_week1.zip	week1\20010608010228.aqa	1393352
	week1\20010608020228.aqa	1393352
	...file names continue at hourly intervals through to...	
	week1\20010613220228.aqa	1393352
	week1\20010613230228.aqa	1393352
	total of 143 files with total volume of	199249336
mia-abs-d02_week2.zip	week2\20010614000228.aqa	1393352
	week2\20010614010228.aqa	1393352
	...file names continue at hourly intervals through to...	
	week2\20010620220228.aqa	1393352
	week2\20010620230228.aqa	1393352
	total of 168 files with total volume of	234083136
mia-abs-d02_week3.zip	week3\20010621000228.aqa	1393352
	week3\20010621010228.aqa	1393352
	...file names continue at hourly intervals through to...	
	week3\20010627220228.aqa	1393352
	week3\20010627230228.aqa	1393352
	total of 168 files with total volume of	234083136
mia-abs-d02_week4.zip	week4\20010628000228.aqa	1393352
	week4\20010628010228.aqa	1393352
	...file names continue at hourly intervals through to...	
	week4\20010704220228.aqa	1393352
	week4\20010704230228.aqa	1393352
	total of 168 files with total volume of	234083136
mia-abs-d02_week5.zip	week5\20010705000228.aqa	1393352
	week5\20010705010228.aqa	1393352
	...file names continue at hourly intervals through to...	
	week5\20010711210228.aqa	1393352
	week5\20010711230228.aqa	921986
	total of 168 files with total volume of	23361170
sd-adp-d01.zip	sd-adp-d01.ctl	4306
	sd-adp-d01.hdr	188490
	sd-adp-d01.ve	815760
	sd-adp-d01.vn	815760

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
sd-adp-d01.zip	sd-adp-d01.vu	815760
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
sd-advo-d01.zip	sd-advo-d01.cti	2492
	sd-advo-d01.hdr	241636
	adv-hdr-fmt.txt	2359
sd-adp-d02.zip	sd-adp-d02.cti	4303
	sd-adp-d02.hdr	204106
	sd-adp-d02.ve	883344
	sd-adp-d02.vn	883344
	sd-adp-d02.vu	883344
	adp-hdr-fmt.txt	1080
	adp-ve-fmt.txt	238
	adp-vn-fmt.txt	236
	adp-vu-fmt.txt	191
	sd-advo-d02.cti	2494
sd-advo-d02.zip	sd-advo-d02.hdr	262081
	adv-hdr-fmt.txt	2359
data_0329.zip	morphology-fmt.txt	
	data_0329\bathyloutput_fin and	
	data_0329\bathyloutput_raw contain the following files	
	nb_032901_line5_b.xyz	
	nb_032901_line6_b.xyz	
	...continues profile by profile (as delineated in the report) through to...	
	nb_032901_line20_b.xyz	
	data_0329\topo contains the following files	
	nb_032901_line5_t.xyz	
	nb_032901_line6_t.xyz	
data_0506.zip	...continues profile by profile (as delineated in the report) through to...	
	nb_032901_line20_t.xyz	
	os_map_032901.out	
	total of 50 files with total volume of	2,782,749
	morphology-fmt.txt	
	data_0506\bathyloutput_fin and	
	data_0506\bathyloutput_raw contain the following files	
	nb_050601_line001_b.xyz	
	nb_050601_line002_b.xyz	
	...continues profile by profile (as delineated in the report) through to...	
data_0530.zip	nb_050601_line020_b.xyz	
	nb_050601_line025_b.xyz	
	...by five lines through...	
	nb_050601_line050_b.xyz	
	nb_050601_line015_b_b.xyz	
	nb_050601_line020_b_b.xyz	
	data_0506\topo contains the following files	
	nb_050601_line005_t.xyz	
	nb_050601_line006_t.xyz	
	...continues profile by profile (as delineated in the report) through to...	
data_0530.zip	nb_050601_line020_t.xyz	
	nb_050601_line025_t.xyz	
	...by five lines through...	
	nb_050601_line050_t.xyz	
	os_map_050601.out	
	total of 84 files with total volume of	7,374,073
	morphology-fmt.txt	
	data_0530\bathyloutput_fin and	

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	data_0530\bathy\output_raw contain the following files nb_053001_line001_b.xyz nb_053001_line002_b.xyz ...continues profile by profile (as delineated in the report) through to... nb_053001_line020_b.xyz nb_053001_line025_b.xyz ...by five lines through... nb_053001_line050_b.xyz nb_053001_line011_b_b.xyz nb_053001_line020_b_b.xyz data_0530\topo contains the following files nb_053001_line005_t.xyz nb_053001_line006_t.xyz ...continues profile by profile (as delineated in the report) through to... nb_053001_line020_t.xyz nb_053001_line025_t.xyz ...by five lines through... nb_053001_line050_t.xyz os_map_053001.out total of 84 files with total volume of 6,172,386	
data_0707.zip	morphology-fmt.txt data_0707\bathy\output_fin and data_0707\bathy\output_raw contain the following files nb_070701_line001_b.xyz nb_070701_line002_b.xyz ...continues profile by profile (as delineated in the report) through to... nb_070701_line020_b.xyz nb_070701_line025_b.xyz ...by five lines through... (except no line045 in \output_fin) nb_070701_line050_b.xyz nb_070701_line018_b_b.xyz data_0707\topo contains the following files nb_070701_line005_t.xyz nb_070701_line006_t.xyz ...continues profile by profile (as delineated in the report) through to... nb_070701_line020_t.xyz nb_070701_line025_t.xyz ...by five lines through... nb_070701_line050_t.xyz os_map_070701.out total of 81 files with total volume of 6,208,828	
data_0806.txt	morphology-fmt.txt data_0806\bathy\output_fin and data_0806\bathy\output_raw contain the following files nb_080601_line001_b.xyz nb_080601_line002_b.xyz ...continues profile by profile (as delineated in the report) through to... nb_080601_line020_b.xyz nb_080601_line025_b.xyz ...by five lines through... nb_080601_line050_b.xyz nb_080601_line009_b_b.xyz nb_080601_line020_b_b.xyz data_0806\topo contains the following files nb_080601_line005_t.xyz nb_080601_line006_t.xyz ...continues profile by profile (as delineated in the report) through to...	

Table 35. Contents of the .zip files contained on DVD01 and the unpacked file size of the component files—Continued.

.zip Filename	Contents	Unpacked File Size (bytes)
	nb_080601_line020_t.xyz nb_080601_line025_t.xyz ...by five lines through... nb_080601_line050_t.xyz os_map_080601.out	
		total of 85 files with total volume of 7,316,498
surface_maps.txt	morphology-fmt.txt surface_maps\os_map_032901.out surface_maps\os_map_050701.out surface_maps\os_map_051501.out surface_maps\os_map_052101.out surface_maps\os_map_052901.out surface_maps\os_map_060701.out surface_maps\os_map_061201.out surface_maps\os_map_062001.out surface_maps\os_map_062601.out surface_maps\os_map_070301.out surface_maps\os_map_070801.out surface_maps\os_map_080701.out	
		total of 13 files with total volume of 2,152,370

APPENDIX D. DESCRIPTION OF DATA FILES

The following tables provide a description of the data files included with the data report.

D.1 SonTek Hydra Systems

Table 36. Column headers for acoustic Doppler velocimeter (ADV) Hydra .HDR files.

Column No.	Contents	Units
1	Burst Number	
2	Year – Start of burst averaging interval	GMT
3	Month – Start of burst averaging interval	GMT
4	Day – Start of burst averaging interval	GMT
5	Hour – Start of burst averaging interval	GMT
6	Minute – Start of burst averaging interval	GMT
7	Second – Start of burst averaging interval	GMT
8	Sampling rate	Hz
9	Samples per burst	
10	Recorded data	
11	Speed of sound used for velocity computations	m/s
12	Distance to the boundary from probe tip (-0.01 if not detected)	cm
13	Distance to the boundary range from center of sampling volume (-0.01 if not detected)	cm
14	Battery voltage	V
15	Mean velocity – East	cm/s
16	Mean velocity – North	cm/s
17	Mean velocity – Up	cm/s
18	Mean signal strength – Receiver 1	counts
19	Mean signal strength – Receiver 2	counts
20	Mean signal strength – Receiver 3	counts
21	Mean correlation – Receiver 1	%
22	Mean correlation – Receiver 2	%
23	Mean correlation – Receiver 3	%
24	Mean heading	degrees
25	Mean pitch	degrees
26	Mean roll	degrees
27	Mean temperature	°C
28	Unused	
29	Mean Paros	dbar
30	Mean optical backscatter sensor (OBS) 1	counts
31	Mean OBS 2	counts
32	Standard deviation of velocity - East	
33	Standard deviation of velocity – North	cm/s
34	Standard deviation of velocity – Up	cm/s
35	Standard deviation of signal strength – Receiver 1	counts
36	Standard deviation of signal strength – Receiver 2	counts
37	Standard deviation of signal strength – Receiver 3	counts
38	Standard deviation of correlation – Receiver 1	%
39	Standard deviation of correlation – Receiver 2	%
40	Standard deviation of correlation – Receiver 3	%
41	Standard deviation of heading	degrees
42	Standard deviation of pitch	degrees
43	Standard deviation of roll	degrees
44	Standard deviation of temperature	°C
45	Unused	
46	Standard deviation of Paros	dbar
47	Standard deviation of OBS 1	counts
48	Standard deviation of OBS 2	counts
49	Unused	
50	Unused	
51	Unused	
52	Unused	

D.2 SonTek ADP

Table 37. Column headers for acoustic Doppler profiler (ADP) .HDR file.

Column No.	Contents	Units
1	Profile number	
2	Year – Start of profile averaging interval	GMT
3	Month – Start of profile averaging interval	GMT
4	Day – Start of profile averaging interval	GMT
5	Hour – Start of profile averaging interval	GMT
6	Minute – Start of profile averaging interval	GMT
7	Second – Start of profile averaging interval	GMT
8	Samples averaged this profile	
9	Speed of sound for velocity computations	cm/s
10	Mean heading	degrees
11	Mean pitch	degrees
12	Mean roll	degrees
13	Mean temperature	°C
14	Mean pressure	dBar
15	Standard deviation of heading	degrees
16	Standard deviation of pitch	degrees
17	Standard deviation of roll	degrees
18	Standard deviation of temperature	°C
19	Standard deviation of pressure	dBar
20	Battery Voltage	V

Table 38. Column headers for acoustic Doppler profiler (ADP) .VE/.VN/.VU files—east (magnetic-eastward positive)/north (magnetic-northward positive)/vertical (up positive) component of velocity for each of 65 cells.

Column No.	Contents	Units
1	Profile number	
2 - 66	Velocity in East/North/Up direction for cells 1-65 (degrees from magnetic North)	cm/s

D.3 SonTek PCADP

Table 39. Column headers for pulse-coherent acoustic Doppler profiler (PCADP) -bm.txt files, burst means files.

Column No.	Contents	Units
1	Julian date	
2	pressure (corrected for atmospheric)	dbar
3	temperature	°C
4	heading	degrees magnetic
5	pitch	degrees
6	roll	degrees
7	OBS1	counts
8	OBS2	counts
9	battery voltage	volts
10	distance to bottom - beam 1	m
11	distance to bottom - beam 2	m
12	distance to bottom - beam 3	m
13	along-beam resolution pulse velocity - beam 1	cm/s
14	along-beam resolution pulse velocity - beam 2	cm/s
15	along-beam resolution pulse velocity - beam 3	cm/s
16	resolution pulse correlation - beam 1	percent
17	resolution pulse correlation - beam 2	percent
18	resolution pulse correlation - beam 3	percent

D.4 Morphology Data Files

Table 40. Column headers for .xyz and .out morphology data files.

Column No.	Contents	Units
1	Easting - NAD83 Washington State Plane South	m
2	Northing - NAD83 Washington State Plane South	m
3	Elevation - NAVD88	m

APPENDIX E. OBS CALIBRATION

This appendix describes laboratory calibrations for the ADV0, ADVF, and PCADP Hydra data loggers and the OBS sensors.

E.1 Voltage to Counts Conversion

Optical backscatter sensors (OBS) measure turbidity and suspended solids concentrations by detecting infrared radiation scattered from suspended matter in a small sampling volume (D&A Instrument Co., 1991). The OBS outputs a voltage between 0 to just over 5 V in response to the amount of light scattered. The OBS output voltage is converted by an analog-to-digital (A/D) converter in the Hydra system and recorded in counts as values between 0 and 65535 (SonTek Inc., 1997).

Calibration of the A/D converter was performed in the laboratory. The output in counts was recorded for applied voltages of approximately 0.0, 1.0, 2.0, 3.0, 4.0, and 5.0 V, and in some cases the maximum convertible voltage was noted. A line was fit to the data, where $\text{counts} = A \cdot V + B$. The results of the calibrations are reported for each Hydra system (table 41). The serial numbers of the OBS can be found in tables 8, 9, and 10. The calibration is specific to the A/D converter and therefore the same calibration applies to both OBS 1 and OBS 2 for that system.

The equations in table 41 were rearranged to convert the OBS data from counts to volts.

Table 41. Response of Hydra system to increased voltage.

[Conversion of optical backscatter (OBS) signal in counts to volts is accomplished by the equation $\text{counts} = A \cdot \text{volts} + B$. (S/N—serial number; ADV0—acoustic Doppler Ocean velocimeter; ADVF—acoustic Doppler Field velocimeter; PCADP—pulse-coherent acoustic Doppler profiler)]

Site	Hydra S/N	Instrument Type	A (counts/V)	B (counts)	R2	No. of Data Points
MD	B51	ADV0	12819	14.257	1.00000	6
MS	B158	ADV0	12824	25.898	1.00000	7
MIA	231	ADVF	12796	40.452	1.00000	7
	244	ADVF	12834	130.95	0.99995	7
	H40	PCADP	12818	8.442	1.00000	7
MIB	B59	ADV0	12827	30.806	1.00000	6
SD	B52	ADV0	12830	29.489	1.00000	6

E.2 Suspended Sediment Calibration

The OBS responds differently depending on the type and size distribution of sediment suspended within its sampling volume (D&A Instrument Co., 1991). Therefore, a calibration for each OBS was performed with sediment collected at the site where each OBS was deployed.

A tank for performing such calibrations was designed and built at the USGS Marine Facilities in Redwood City, Calif. The tank suspends a known amount of sediment in a known amount of water using methods similar to those described in Downing and Beach (1989). The response of the OBS in volts at various sediment concentrations is recorded over a period of 30 seconds, and the average voltage is taken as a representative reading for that concentration of suspended sediment.

The calibrations were done through the full range of voltage output of the OBS, approximately 0 to 5 volts, at suspended sediment concentrations between 0 and 10 kg/m³ at 0.5 kg/m³ intervals for nearly all OBS.

The maximum output of good OBS data during the Grays Harbor summer 2001 experiment never exceeded 5000 counts, or approximately 0.5 V. The response of the OBS deployed in the Grays Harbor Spring 2001 Experiment to the suspended sediment in this area appears to be linear in the range from 0 to beyond 1.5 kg/m³. Therefore, a line was fit to the calibration data collected at concentrations ranging up to approximately 1.5 kg/m³ (fig. 137). This line is the best-fit line based on four data points, three for Site MD. The line takes the form of $\text{Volts} = C \cdot \text{Conc} + D$. The results for each OBS deployed during the experiment are reported in table 42.

One sediment sample, MI, was taken to be representative of the sediment at both Sites MIA and MIB because of their close proximity during the deployment. The OBS for Sites MIA and MIB were therefore calibrated with sediment sample MI.

OBS S/Ns 796, 924, and 1244 were unavailable for post-experiment sediment calibration. Based on Formazin (a standard reference suspension which has reproducible light scattering properties) calibrations were performed previous to deploying the OBS, and knowledge of the sediments at the deployment sites, the sediment calibration equations for OBS S/Ns 1135, 925, and 1243 should be used for S/Ns 796, 924, and 1244, respectively.

The equations in table 42 were rearranged to convert the OBS data to suspended sediment measurements.

Table 42. Optical backscatter sensor (OBS) calibration equations from sand calibrations.

[Conversion of OBS signal in volts to kg/m³ is accomplished by using the equation $\text{volts} = C \cdot (\text{kg/m}^3) + D$. (S/N—serial number)]

Site	Hydra S/N	OBS S/N	<i>C</i> (V/(kg/m ³))	<i>D</i> (V)	R ²	No. of Data Points
ND	B45	795	0.36822	0.04487	0.99795	4
		796	0.36354*	0.03607*	0.99995*	3*
MD	B51	1242	0.33966	0.01337	0.99815	3
		1135	0.36354	0.03607	0.99995	3
MS	B158	928	0.34059	0.06665	0.99383	4
		1104	0.35955	0.05486	0.99658	4
MIA	231	829	0.34196	0.02640	0.99284	4
		830	0.34646	0.03119	0.99454	4
	244	924	0.24210*	0.07163*	0.97933*	4*
		925	0.24210	0.07163	0.97933	4
	H40	694	0.33370	0.05367	0.99279	4
		794	0.34618	0.03274	0.99359	4
MIB	B59	1244	0.31320*	0.03009*	0.98900*	4*
		1429	0.28366	0.07790	0.99841	4
SD	B52	1243	0.31320	0.03009	0.98900	4
		1428	0.32184	0.03978	0.99568	4

* OBS were unavailable for post-experiment sediment calibration. Coefficients have been suggested based on the response of predeployment Formazin calibrations and knowledge of sediment types at the sites.

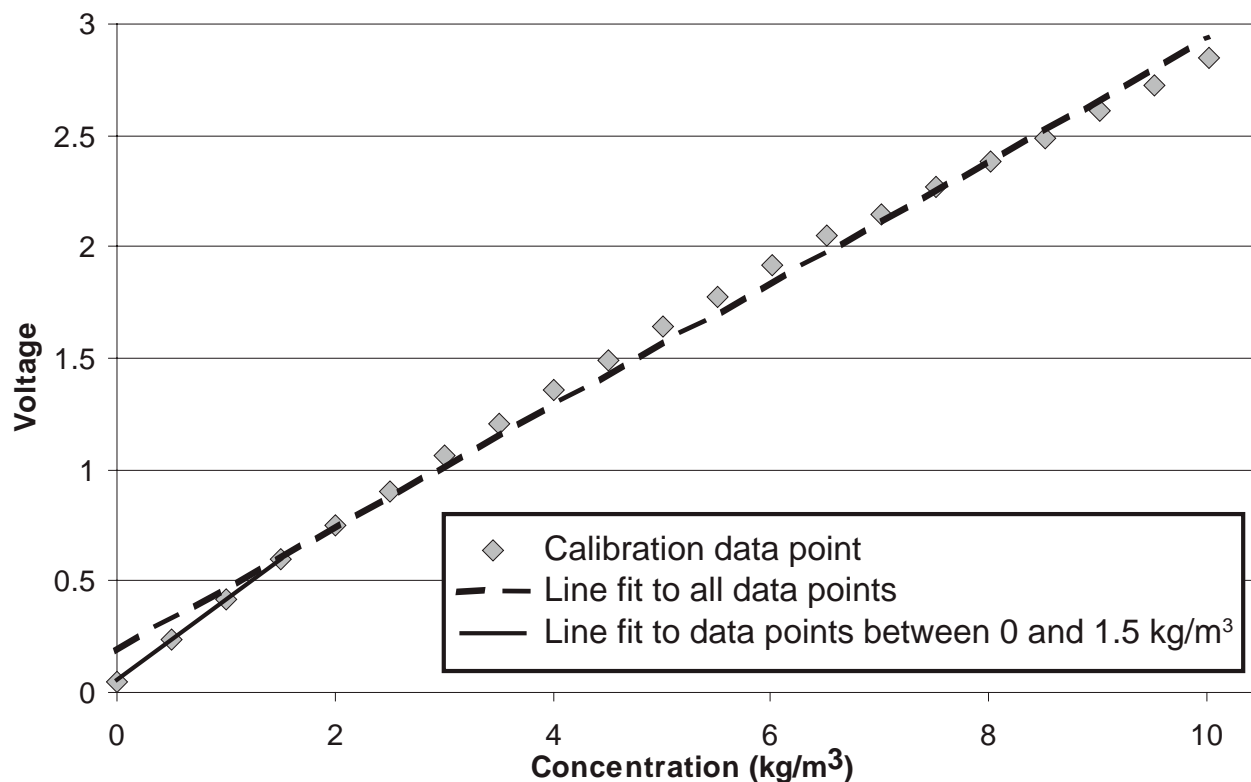


Figure 137. Various lines fit to the optical backscatter sensor (OBS) calibration data points for Site ND OBS serial number 830. The line which best represents the calibration data is fit to the section of the data which best represents the range of the experiment measurements, 0 to 0.5 V. The data points from the calibration are shown as grey diamonds. A first-order least-squares fit line, fit to all calibration data points, is shown by the black dashed line. The black solid line shows a first-order least-squares fit line fit to just the four data points between 0 and 1.5 kg/m³ sediment concentration. Results are similar for all calibrated OBS.

APPENDIX F. OBS INTERFERENCE

Inspection of the within-burst time series of OBS data showed the presence of an artifactual sinusoidal signal superimposed on the data. The frequency of the signal is the same for the two OBS connected to a Hydra system, and the amplitudes are similar. Frequency and amplitude vary considerably from pair to pair (fig. 138). The amplitude of the sinusoid is the same order of magnitude as the environmental signal, and the frequency typically overlaps the range of frequencies associated with resuspension (that is, wave frequencies). The interference was not optical; we were able to reproduce it in the laboratory with OBS that had black plastic tape covering the receivers. Initial investigations indicate that the phenomenon is beating caused by the interference of the two OBS crystals which emit electromagnetic signals at slightly different frequencies, but we have not fully investigated the source of the problem nor methods for avoiding it. The purpose of this appendix is to present an approach to removing the erroneous signal in order to recover the data collected in the Grays Harbor 2001 experiment. This approach significantly reduces the error in the data, but does not completely remove it. We do not recommend this approach for future collection of high-frequency OBS data: it is intended to salvage data contaminated by an unanticipated error. In the future we recommend that the source of the interference be identified and prevented, or that only one OBS be deployed on each Hydra system.

Initially we hoped to remove the interference signal by filtering. However, because the frequency of the sinusoids overlapped the frequencies of interest in the data, attempts to filter with a narrow stop-band were not satisfactory; parts of the “true” signal were removed and there was ringing at the ends of the bursts.

Instead, a method was developed based on Fourier decomposition. This approach was selected because the interference signal has a single frequency. In concept, removal of a single frequency signal is straightforward. The challenge is in accurately determining the frequency and phase, because subtraction of a sinusoid with a frequency or phase that is slightly different from the interference signal would introduce large errors into the data.

A discrete Fourier transform decomposes a signal into frequencies that are integer multiples of $1/n\Delta t$, where n is the number of data points and Δt is the sampling interval. The approximate frequency with the greatest energy is identified by performing a Fourier transform on the entire burst. To more accurately identify the interference frequency, Fourier decomposition is applied to successively shorter sections of the burst, which varies the frequencies that are analyzed. For example, consider a data record consisting of 100 samples at 1-s intervals, with a ‘true’ interference frequency of 0.095 s^{-1} . Decomposition of the full record provides information about frequencies of $9/100=0.09\text{ s}^{-1}$ and $10/100=0.1\text{ s}^{-1}$. After truncation to 98 data points, decomposition yields information about the frequency $9/98=0.918\text{ s}^{-1}$, which will have a greater amplitude than 0.09 s^{-1} . In this example, the procedure would continue until the record is truncated to 95 points and would identify the frequency $9/95=0.947\text{ s}^{-1}$ as the interference frequency, after determining that the energy in $9/94=0.957\text{ s}^{-1}$ is lower than the energy at 0.947 s^{-1} (because it is further from the ‘true’ frequency).

This iterative approach produces a relatively accurate estimate of both the frequency and amplitude of the interference signal. However, the amplitude detected by this method can vary because in some bursts the environmental signal produces considerable energy at the same or similar frequencies as the interference signal. Furthermore, the estimate of frequency is limited to those analyzed by truncating the record length. We conducted the analysis on the first 200 bursts of each record. Plots of the results show a central tendency and outliers, and the median is used as a best estimate of the amplitude and frequency of the interference signal (fig. 139). The OBS pairs on the ADVFs produced very low-frequency interference signals with periods greater than five minutes.

The frequency and amplitude of the signals could not be determined by this method (and are not included in table 43) because there were so few cycles in each burst.

This approach worked reasonably well for determining the amplitude and frequency of the interference signal, but was not reliable for determining phase, which varies from burst to burst. The frequencies and amplitudes for the OBS pairs used in the Grays Harbor experiment are shown in table 43. To determine phase, we use a least-squares fit between the data and a sine-wave with frequency determined as described above, for each burst. The least-squares fit predicts amplitude and phase for each burst. The least-squares fit amplitudes were consistent with the amplitudes determined from the Fourier decomposition.

The final step is to clean the OBS data by subtracting a signal with the frequency and amplitude determined by the Fourier decomposition and the burst-specific phase determined by the least-squares fit method. After cleaning, the amplitude of the interference is much reduced, however, at times when suspended sediment concentration is low, remnants of the interference can be seen (fig. 140).

The following Matlab codes implementing the interference removal described here are included on DVD02:

- **FINDFREQ.m** is a function that estimates the frequency, amplitude, and phase of the sine wave interference (due to multiple OBS) in a single burst of OBS data. **FINDFREQ.m** finds the frequency with the most energy by performing a fast-Fourier transform on successively shorter data records.
- **ADVOBS.m** is a script that estimates the frequency, amplitude, and phase of the sine wave interference in OBS data records (or selected bursts) from the spring 2001 experiment, by applying **FINDFREQ.m**. **ADVOBS.m** also produces some statistics on the amplitudes and phases, so values can be chosen for cleaning the entire record. The user needs to edit the paths to the data files as appropriate and choose the correct path for the data file of interest by uncommenting the appropriate line.
- **PC_OBS.m** is a script that finds the frequency and amplitude of the OBS-interference signal from **pcadp.mat** files, by calling **FINDFREQ.m**. It is analogous to **ADVOBS.m**, but it is for **PCADP** data. The user needs to edit the paths to the data files as appropriate, and choose the correct path for the data file of interest by uncommenting the appropriate line.
- **OBSCLLSF.m** is a function that uses a least-squares fit to find the amplitude and phase of the sine wave interference (due to multiple OBS) for single bursts of OBS data. The user must input a frequency and amplitude (may be from table 43, or determined by **ADVOBS**). Then the burst is cleaned using the pre-determined frequency and amplitude and the burst-specific phase. **OBSCLLSF.m** also gives the error of the least-squares fit.
- **ND2OBSLSF.m** is an example script that uses the frequency and amplitude output from **ADVOBS.m** to clean a data record (or selected bursts) using **OBSCLLSF.m**. This example is for data from Site ND collected during Deployment 2 of the spring 2001 Grays Harbor experiment, and can serve as a model for codes for the other sites. The user needs to edit the path to the data file as appropriate.

These m-files require the use of several m-files that are provided as part of the Matlab Statistics Toolbox. **ADVOBS.m** and **ND2OBSLSF.m** call **ADR2MAT.m**. (**ADR2MAT.m** is part of **CMGTools** (Xu and others, 2002), a software package for processing, analyzing, and visualizing time-series oceanographic data. This report can be found at <http://geopubs.wr.usgs.gov/open-file/of02-19/>.) **ADR2MAT.m** is provided on DVD02.

These m-files are provided as examples for users. The validity and usability of the m-file is in no way guaranteed by the USGS or the authors of the report or the m-file; use is at your own risk.

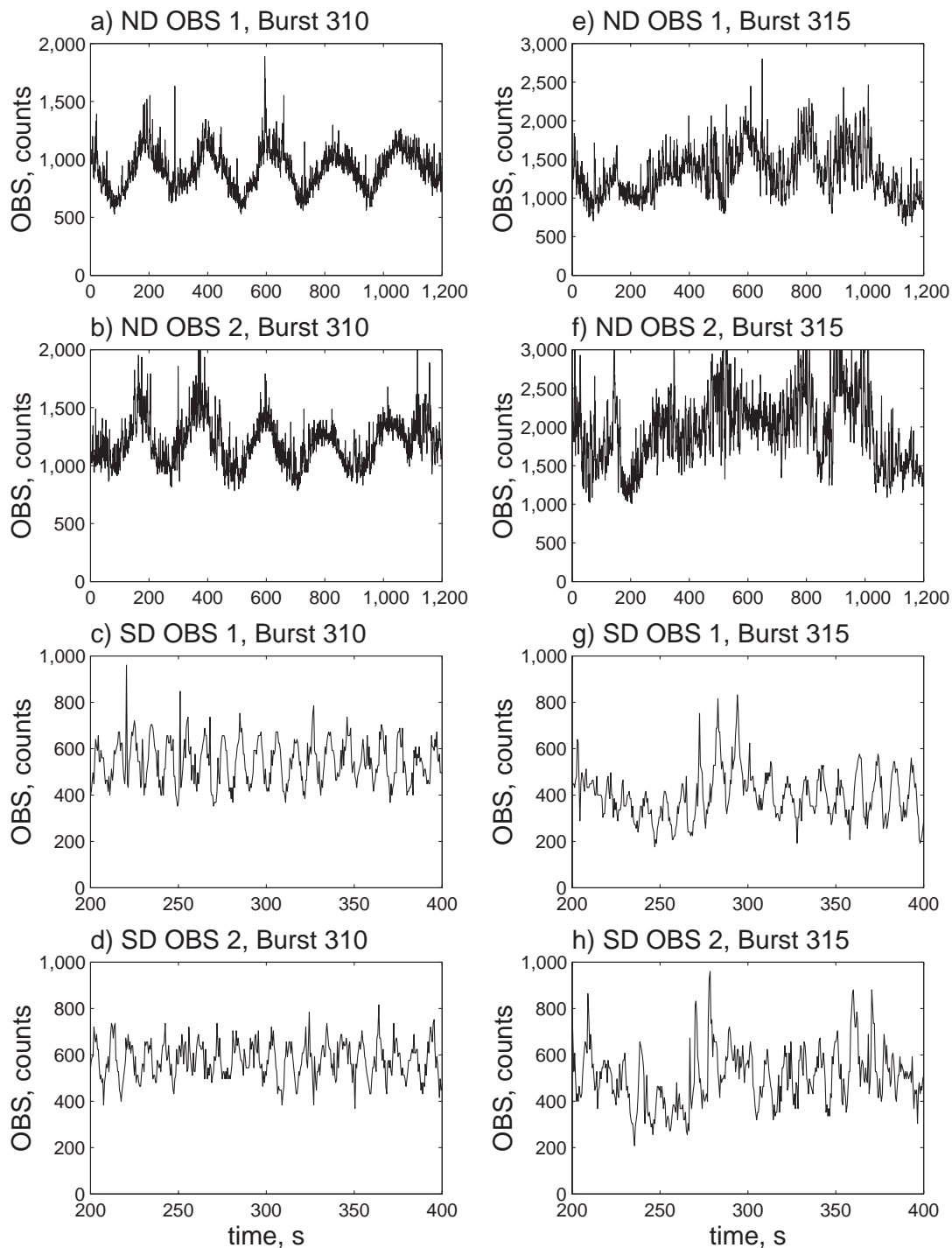


Figure 138. Examples of interference in optical backscatter (OBS) time series. The frequency of the interference is the same for any two OBS on the same Hydra system (compare a and b), but differs between pairs (compare b and c, noting difference in scale on time axes). The interference is obvious when temporal variation in suspended sediment concentration is low (subplots a-d). When the variation in suspended sediment concentration is greater (subplots e-h) the interference is more difficult to discern but still contributes significant error to the time series.

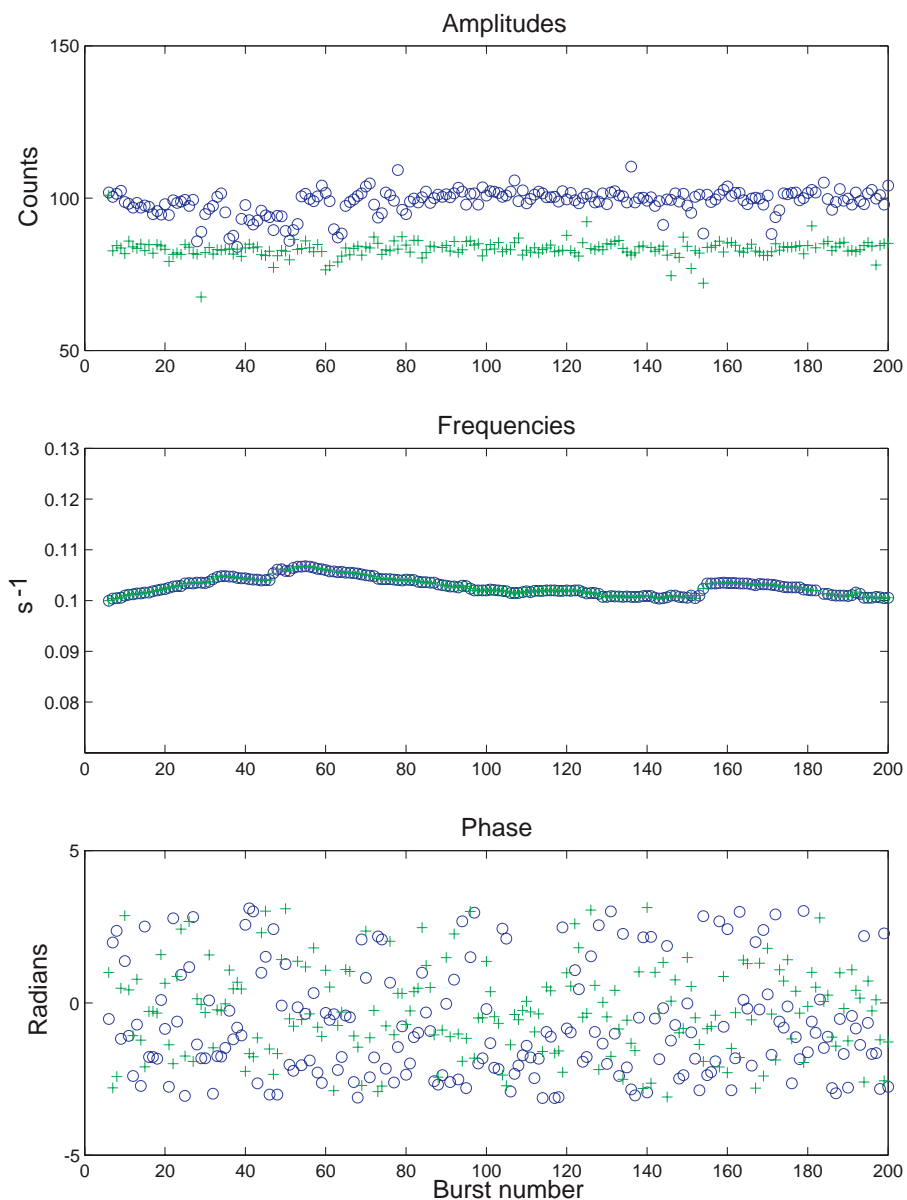


Figure 139. Example of amplitudes, frequencies, and phases determined by ADV OBS.m. These results are for the first 200 bursts of Deployment 2 at Site SD. Blue circle is optical backscatter sensor no. 1 (OBS1); green cross is optical backscatter sensor no. 2 (OBS2).

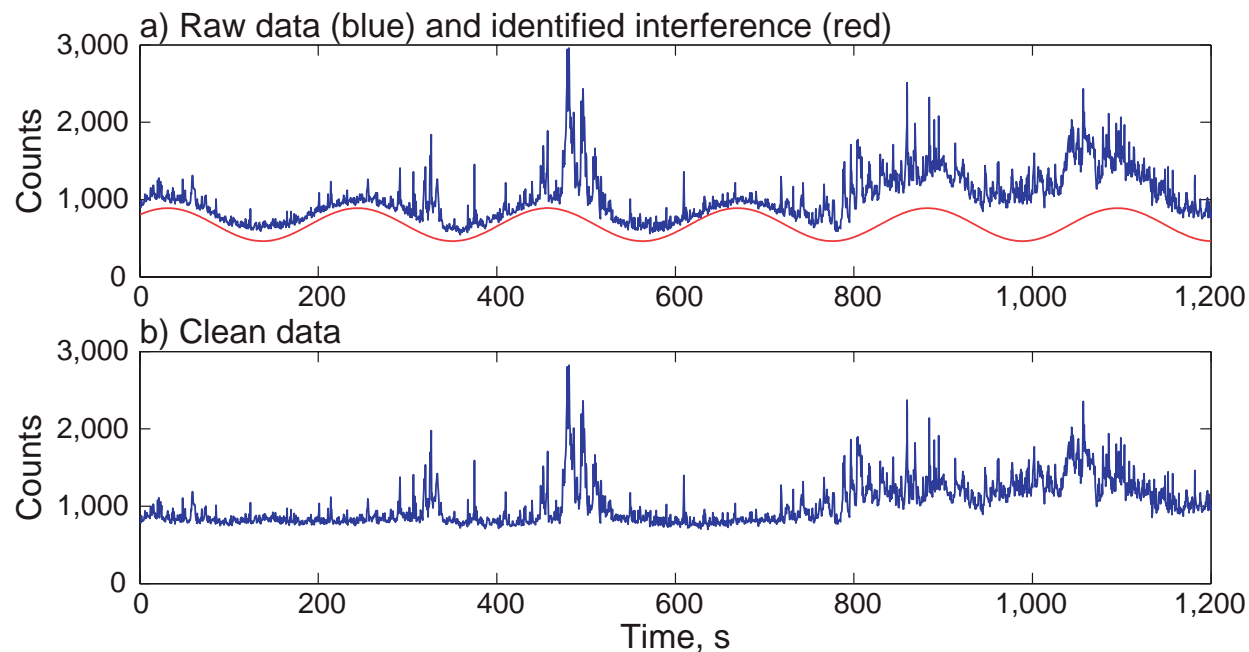


Figure 140. Example of a cleaned-up time series of optical backscatter (OBS) data from OBS2 at Site ND Deployment 2 burst 91. Note that the interference signal in subplot a is offset to facilitate comparison with data. The subtracted interference has a zero mean.

Table 43. Frequencies and amplitudes of interference signals for optical backscatter sensor (OBS) pairs used in spring 2001 Grays Harbor experiment.

[These values can be used in running OBSCLLSF.m. (S/N—serial number; ADV0—acoustic Doppler Ocean velocimeter; PCADP—pulse-coherent acoustic Doppler profiler)]

Site	Instrument Type	OBS S/N	Deployment 1		Deployment 2	
			Frequency cycles/s	Amplitude counts	Frequency cycles/s	Amplitude counts
ND	ADV0	OBS 1 795	0.00464	174	0.00464	173
		OBS 2 796		180		179
MD	ADV0	OBS 1 1242	0.04350	128	0.04380	127
		OBS 2 1135		130		131
MS	ADV0	OBS 1 928	0.00250	167	0.00250	168
		OBS 2 1104		159		157
MIA	PCADP	OBS 1 694	0.00878	174	0.08750	174
		OBS 2 794		190		187
MIB	ADV0	OBS 1 1244	0.16180	130	0.16160	130
		OBS 2 1429		105		110
SD	ADV0	OBS 1 1243	0.1030	100	0.10230	100
		OBS 2 1428		85		84

